ONTARIO ASSESSMENT INSTRUMENT POOL

DRAFT

OAC BIOLOGY

UNIT V

THEORY OF EVOLUTION

ONTARIO ASSESSMENT INSTRUMENT POOL

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OAC BIOLOGY

UNIT V

THEORY OF EVOLUTION

Queen's Park
Toronto, Ontario

ISBN 0-7729-6270-7
CD 08710

Canadian Cataloguing in Publication Data

Main entry under title:

OAC Biology

On cover: Ontario assessment instrument pool.
"Draft".
ISBN 0-7729-6270-7

1. Biology–Study and teaching (Secondary)–Ontario.
2. Biology–Ability and testing. I. Ontario. Ministry of Education. II. Title: Ontario assessment instrument pool.

QH316.024 1989 574'.076 C89-099669-5

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B051AaMC.01
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 51Aa
UNIT NUMBER: 05	INSTRUMENT TYPE: MC
UNIT NAME: THEORY OF EVOLUTION	KLOPFER: A.1, A.2, A.3, A.9, I.1, I.3
	DIFFICULTY LEVEL: M
TOPIC: Scientific Theories	TIME ALLOCATION:
CURRICULAR EMPHASIS: Nature of Science	

KEYWORDS: evolutionary theory

Guideline Objective

The student will be encouraged to develop an appreciation of the development and the explanatory value of the neo-Darwinian theory of biological evolution.

Item Focus

The student will identify the importance of evolutionary theory in biology.

Item

Which of the following is the most important reason for studying biological evolution?

☐ A. Evolution is a reductionist explanation (suborganismic).

☐ B. Evolution is a unifying theory in biology.

☐ C. Evolution can be verified through scientific experimentation.

☐ D. One cannot understand areas in biology such as physiology and genetics unless one has studied biological evolution.

☐ E. Evolution demonstrates the importance of molecular biology.

Response/Marking Scheme

Correct response: B

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B051AaMC.02
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 51Aa
UNIT NUMBER: 05	INSTRUMENT TYPE: MC
UNIT NAME: THEORY OF EVOLUTION	KLOPFER: A.1, A.2, A.3, A.8, A.9, I.2
	DIFFICULTY LEVEL: M
TOPIC: Scientific Theories	TIME ALLOCATION:
CURRICULAR EMPHASIS: Nature of Science	

KEYWORDS: evolutionary theory Darwin

Guideline Objective

The student will be encouraged to develop an appreciation of the development and the explanatory value of the neo-Darwinian theory of biological evolution.

Item Focus

The student will recognize scientific attributes of neo-Darwinian evolutionary theory.

Item

Neo-Darwinian evolutionary theory is accepted as plausible within science because:

I evidence supporting the theory exists from a variety of different sources.

II the ideas within the theory are coherent with ideas from other branches of science.

III the theory forms the basis of explanations concerning similarities and differences between organisms.

IV the theory is in accord with accepted scientific practices.

V uniformitarianism is followed.

Which of the following represents the best combination of correct statements?

☐ A. I, IV

☐ B. I, II

☐ C. I, II, III

☐ D. I, II, III, IV

☐ E. I, II, III, IV, V

Response/Marking Scheme

Correct response: E

Teacher Notes

DRAFT

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 05
UNIT NAME: THEORY OF EVOLUTION

TOPIC: Scientific Theories
CURRICULAR EMPHASIS: Nature of Science

INSTRUMENT CODE: B051AbMC.01
GUIDELINE OBJECTIVE CODE: 51Ab
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.9, I.1, 1.2
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS:

Guideline Objective

Students will be encouraged to develop a curiosity about the natural mechanisms that are explained by means of the theory of biological evolution and the usefulness and limitations of the theory.

Item Focus

The student will recognize the function of a scientific theory.

Item

The major purpose of scientific theories is

☐ A. to explain natural phenomena.

☐ B. to develop scientific laws.

☐ C. to help visualize scientific explanations.

☐ D. to generate principles.

☐ E. to describe natural phenomena.

Response/Marking Scheme

Correct response: A

Teacher Notes

DRAFT

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B051AbER.01
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 51Ab Part 1(3.3e)
UNIT NUMBER: 05	
UNIT NAME: THEORY OF EVOLUTION	INSTRUMENT TYPE: ER
	KLOPFER: A.1, A.2, A.3, A.9, I.1
TOPIC: Scientific Theories	DIFFICULTY LEVEL: M
CURRICULAR EMPHASIS: Nature of Science	TIME ALLOCATION:

KEYWORDS: Darwin evolutionary theory

Guideline Objective

The student will be expected to recognize not only the usefulness of science but its limitations as well; to know that scientific knowledge is subject to change; and to distinguish between scientific fact and personal opinion.

Item Focus

The student will understand that scientific concepts do not have the characteristic of certainty about them.

Item

In his book, *The Descent of Man,* Darwin said: "False facts are highly injurious to the progress of science, for they often endure long; but false views, if supported by some evidence, do little harm, for everyone takes....pleasure in proving their falseness; and when this is done, one path towards error is closed and the road to truth is often at the same time opened."

A. Explain the meaning of the term "fact" as it is used in this passage.

B. State why scientists attempt to uncover the "falseness" of views, but according to Darwin do not do the same for "facts".

Response/Marking Scheme

A. In this passage, the term "fact" seems to mean something that is unquestioned: that is, it is accepted as being certainly truth, or absolutely true. 2

B. Views are regarded as ideas that can be challenged, 2
particularly if other viewpoints exist. On the other hand, because facts are regarded (in the context of Darwin) as being certain truths, there is no attempt to investigate them, as this would appear to be pointless. 2

Possible: 6

Maximum: 6

DRAFT

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B051AcER.01
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 51Ac
UNIT NUMBER: 05	INSTRUMENT TYPE: ER
UNIT NAME: THEORY OF EVOLUTION	KLOPFER: A.1, A.3, A.9, I.3
	DIFFICULTY LEVEL: H
TOPIC: Scientific Theories	TIME ALLOCATION:
CURRICULAR EMPHASIS: Science, Technology and Society	

KEYWORDS: origin of species evolution/creation debate

Guideline Objective

Students will be encouraged to develop an appreciation of the differences between the origin, development, and nature of scientific theories and other non-scientific modes of explanation, for example, religious.

Item Focus

Students will reconstruct arguments and reasons for the debate over the plausibility of evolutionary explanations of the origin of species.

Item

Explanations for the origin of species have been the subject of considerable debate over the years.

A. Explain 2 major points that are debated within the discipline of science concerning the status of evolution as a scientific theory. Be sure to give both sides of the debate.

B. Explain 2 major points that are debated by evolutionists and creationists. Be sure to give both sides of this debate.

Response/Marking Scheme

A. Some philosophers of science have argued that evolutionary theory does not have the capability of predicting forms of organisms in the future, thus on this account, it loses some of its status as a theory. 1

The counter-argument is two-fold. First, some theories do not predict the outcome for specific events (such as the velocity and position of a single gas particle in a container). 1

Rather, what is predicted is group characteristics (e.g. volume, pressure, etc.). Similarly, it can be argued that evolutionists could predict general trends of groups of organisms if the selective factors could be specifically stated. 1

The second argument deals with the concept of prediction. There is no stipulation that prediction must deal specifically with future events. 1

On the contrary, prediction could also occur with respect to events in the past that are open to interpretation. Thus, "postdiction" is a way of adding confidence to evolutionary theory. 1

B. Creationists argue that God created the earth in a manner that is close to, if not exactly like that outlined in Genesis. This means that all species were created in the form which they have today. 1

Thus, creationists argue that there is no evidence to support the evolutionist claim that man descended from less complex organisms over extremely long periods of time. 1

Creationists further claim that fossils of extinct, human-like creatures are not ancestors of humans, but rather organisms that simply became extinct. 1

Evolutionists counter by claiming that evidence from a variety of sources (biochemical, paleotological, comparative anatomy, geographical distribution, etc.) supports the theory of evolution. 1

Furthermore, radioactive dating of soil in which fossils are found is used to determine the age of the fossils, and it is claimed that the hominid fossils can be sequenced. 1

Creationists also argue that the earth is significantly younger than the age proposed by evolutionists and geologists. 1

Since creationists do not accept the consistent application of the principle of uniformitarianism, they claim that not only conditions, but also the manner in which natural phenomena occurred in the past was significantly different from today. 1

Thus extending present day explanations into the past is thought to yield erroneous conclusions. 1

Evolutionists, on the other hand, argue that the earth is approximately 4.5 billion years old. 1

Using the principle of uniformitarianism, and modern applications of radioactive dating, they present evidence in support of their claim. 1

In both cases, the data considered as evidence is filtered through a belief system. In the case of evolutionists, the belief system is that of science, while for creationists, the belief system is that of religion. 2

Possible: 17

Maximum: 13

Quality: 2

Total: 15

Teacher Notes

DRAFT

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B051AcER.02
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 51Ac
UNIT NUMBER: 05	INSTRUMENT TYPE: ER
UNIT NAME: THEORY OF EVOLUTION	KLOPFER: A.1, A.2, A.3, A.5, H.3, I.2, I.3
	DIFFICULTY LEVEL: M
TOPIC: Scientific Theories	TIME ALLOCATION:
CURRICULAR EMPHASIS: Science, Technology and Society	

KEYWORDS: creation evolution/creation debate gradual change fossil record

Guideline Objective

Students will be encouraged to develop an appreciation of the differences between the origin, development, and nature of scientific theories and other non-scientific modes of explanation, for example, religious.

Item Focus

The student will state that religious and scientific interpretations depend on different beliefs.

Item

Creationists are people who believe in the literal Biblical account of the creation of the earth and its inhabitants. Creationists do not accept the theory of organic evolution. Evolutionists accept the theory of the evolution of organisms so that those that survive are better adapted to their environment than those that become extinct. In rock formed during the Cambrian period (estimated to be about 600 million years ago), most of the major phyla of invertebrates are represented in the fossil record. Evolutionists believe that these fossils were formed during the geologically brief period of a few million years.

A. How do some creationists interpret the fossil data?

B. How do some creationists establish the "truth" or plausibility of their interpretation?

C. How do evolutionists interpret the fossil data?

D. How dO evolutionists establish the "truth" or plausibility of their interpretation?

Response/Marking Scheme

A. Creationists dispute that the data represent evidence supporting or refuting evolution. 1

One issue that creationists dispute is the estimated age of the rock formations. Usually they argue for a much younger earth. 1

Creationists might argue that the appearance of so many different types of complex organisms during the Cambrian period might indicate that this corresponded to the period when God created the earth and its inhabitants. 1

B. Creationists would establish the truth of their contentions by referring to the writings in the Bible. For creationists, the Bible is the ultimate authority on the subject. 1

C. Evolutionists argue that simpler forms of life must have existed before the Cambrian fossils were formed. 1

These simpler forms would have been present during the Pre-Cambrian period. Although many simpler forms have been found, presumably many forms were not fossilized, for a variety of reasons. One plausible reason is that the organisms in the Pre-Cambrian period did not possess extensive hard parts. Their soft parts usually were not fossilized. 1

An alternative explanation might be that during the Cambrian period, there was a rapid evolution of a wide variety of organisms. 1

D. Evolutionists establish the truth of their conclusions using evidence and rational arguments from a variety of sources. 2

For example, the age of rocks is plausibly established through radioactive dating techniques.

Possible: 9

Maximum: 6

Teacher Notes

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DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B051SbMC.01
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 51Sb
UNIT NUMBER: 05	INSTRUMENT TYPE: MC
UNIT NAME: THEORY OF EVOLUTION	KLOPFER: A.1, A.2, A.3, A.5, A.8, I.3
	DIFFICULTY LEVEL: M
TOPIC: Theories of Evolution	TIME ALLOCATION:
CURRICULAR EMPHASIS: Nature of Science	

KEYWORDS: Darwin/Wallace Lamarck

Guideline Objective

Students will have the opportunity to develop skill in abstracting information from reading selections on evolutionary theory and identifying the main ideas, the argument sequence and the authors' points of view.

Item Focus

The student should be able to evaluate statements in terms of the theories of Darwin/Wallace and Lamarck.

Item

The Darwin/Wallace theory of natural selection and the Lamarckian theory are based on several statements, some of which are observations, and some are conclusions (inferences).

Consider the following statements.

I Many types of variations exist within any species.

II If all offspring of a species were to survive, the population would increase in a geometric ratio from generation to generation.

III Some variations have more survival value than others.

IV Although organisms have a tendency to increase in number, the population of a given species tends to remain constant.

V There is a struggle for survival.

VI Organisms are better able to adapt to their environment when they inherit variations that have been developed by their parents through use and disuse of certain organs.

Statement V is a logical conclusion from statements

☐ A. I and II

☐ B. II and III

☐ C. II and IV

☐ D. III and IV

☐ E. III and VI

Response/Marking Scheme

Correct response : C

Teacher Notes

DRAFT

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 05
UNIT NAME: THEORY OF EVOLUTION

TOPIC: Theories of Evolution
CURRICULAR EMPHASIS: Nature of Science

INSTRUMENT CODE: B051SbMC.02
GUIDELINE OBJECTIVE CODE: 51Sb
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3, A.5, A.8, L.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: Darwin/Wallace Lamarck

Guideline Objective

Students will have the opportunity to develop skill in abstracting information from reading selections on evolutionary theory and identifying the main ideas, the argument sequence and the authors' points of view.

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V There is a struggle for survival.

VI Organisms are better able to adapt to their environment when they inherit variations that have been developed by their parents through use and disuse of certain organs.

Darwin and Wallace would <u>NOT</u> have agreed with statement

☐ A. I.

☐ B. II.

☐ C. III.

☐ D. V.

☐ E. VI.

Response/Marking Scheme

Correct response: E

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 05
UNIT NAME: THEORY OF EVOLUTION

TOPIC: Theories of Evolution
CURRICULAR EMPHASIS: Nature of Science

INSTRUMENT CODE: B051SbMC.03
GUIDELINE OBJECTIVE CODE: 51Sb
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3, A.5, A.8, I.3
DIFFICULTY LEVEL: M
TIME ALLOCATION:

KEYWORDS: Darwin/Wallace Lamarck

Guideline Objective

Students will have the opportunity to develop skill in abstracting information from reading selections on evolutionary theory and identifying the main ideas, the argument sequence and the authors' points of view.

Item Focus

The student should be able to evaluate statements in terms of the theories of Darwin/Wallace and Lamarck.

Item

The Darwin/Wallace theory of natural selection and the Lamarckian theory are based on several statements, some of which are observations, and some are conclusions (inferences).

Consider the following statements.

I Many types of variations exist within any species.

II If all offspring of a species were to survive, the population would increase in a geometric ratio from generation to generation.

III Some variations have more survival value than others.

IV Although organisms have a tendency to increase in number, the population of a given species tends to remain constant.

V There is a struggle for survival.

VI Organisms are better able to adapt to their environment when they inherit variations that have been developed by their parents through use and disuse of certain organs.

According to Lamarck, statement I could be best explained by accepting statement

☐ A. II.

☐ B. III.

☐ C. IV.

☐ D. V.

☐ E. VI.

Response/Marking Scheme

Correct response: E

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B051SbEE.01
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 51Sb
UNIT NUMBER: 05	INSTRUMENT TYPE: ER
UNIT NAME: THEORY OF EVOLUTION	KLOPFER: A.1, A.2, A.3.
	DIFFICULTY LEVEL: H
TOPIC: Genetic Basis of Evolution	TIME ALLOCATION:
CURRICULAR EMPHASIS: Communications	

KEYWORDS: peppered moth

Guideline Objective

Students will have the opportunity to develop skill in abstracting information from reading selections on evolutionary theory and identifying the main ideas, the argument sequence, and the authors' points of view.

Item Focus

As above.

Item

This question involves analysing excerpts from two biology textbooks, in which the authors differ in their points of view on the same topic.

Read the following paragraphs, and answer the questions that follow.

A. "The following case . . . involves the peppered moth population in the region of Manchester, a British industrial city.

"Before 1845, the peppered moth was light-colored with a pattern of dark specks. It could hardly be seen when it rested on the light gray bark of trees. Then, in 1845, an almost completely black peppered moth was found in Manchester. A gene for colour had mutated.

"Normally this mutation would be harmful. A black moth on light bark would be easy prey for birds. But something else was happening in Manchester. The city was becoming an industrial center. Coal smoke pouring from factory chimneys was turning gray tree bark nearly black all over the area. In the changed environment a mutation for dark color was very helpful, since birds couldn't see the dark moths as well on dark trees.

"The results of these changes are a good example of the theory of evolution in action. Between 1845 and 1895, the black moth population increased from a few individuals to <u>99% of the population</u>. Because of natural selection in a new environment, the peppered moth had completely changed color in only 50 years!"

Otto, Towle, and Bradley: *Modern Biology*, Holt, Rinehart and Winston of Canada, 1982.

1. List the four main ideas presented in the excerpt above.

2. Discuss whether the paragraphs represent accurately what actually happened to the population of peppered moths.

3. In the 1960's, Britain enforced tough laws against air pollution. What change occurred in the population of peppered moths? How would the authors of the quoted paragraph have to explain the change?

B. "Consider the case of *Biston betularia*, the peppered moth. It is a common inhabitant of English woodlands. To a casual observer all peppered moths look alike. But, if you examine a large number of them carefully, you find — as in all populations — many individual differences. . . Some individuals are light and others dark.

". . . Biologists find that the variations among moths caught in 1850 are mainly the same as those among moths collected a hundred years later. But there is one startling difference. Among moths collected in 1950, there are more dark than light ones. In 1850 there were many more light than dark moths.

"However, if biologists examine only rural southern England moths from 1950, they find a ratio of light to dark like that of 1850. It is when they examine collections from the heavily industrialized Midlands of England that they find very few light moths. Why should light moths predominate in one region and dark moths elsewhere? And why should dark moths have been rarer in the past than now?

"The biologists . . . developed a hypothesis that they proceeded to test. In the Midlands they placed both light and dark moths on smoke-blackened tree trunks. . . The biologists soon observed that birds ate more light than dark moths. Both light and dark moths were then placed on trees common to southern England — soot-free and encrusted with white lichens. Here the birds ate more dark than light moths.

"What can we conclude from the experiments? In the industrialized Midlands the tree trunks became covered with black soot. Dark moths survive predation better than white moths on these trees. Moth coloration is

controlled genetically. During the last century, therefore, Darwin's natural selection favored the moths most protectively colored in the new environment."

BSCS Green Version. *Biological Science: An Ecological Approach*, 5th Ed.,Houghton Mifflin Company, 1982.

4. In what way does this account differ from Excerpt A?

5. How does Excerpt B show the way scientists work?

6. How would the authors of Excerpt B explain what happened to the populations of peppered moths when the stricter laws against air pollution were enforced?

Response/Marking Scheme

Excerpt A

1. A mutation occurred, changing white colouration to black. The environment changed, soot darkened the tree trunks. Birds ate nearly all the conspicuous white moths. The population of peppered moths became almost completely black. 4
2. The account is oversimplified. 1

   Both light and dark moths must have been present in the population for eons. 1

   Each colour phase has a selective advantage under different conditions: 1

   light moths would be concealed at rest on tree trunks covered with light-coloured lichens; 2

   dark moths would be inconspicuous at rest on black soil, and in flight during the day. 2

   A change in the environment changed the selection pressure, removing the advantage of light moths at rest on bark. 2
3. After air pollution was reduced, light-coloured lichens returned to the tree trunks, and the percentage of the light moths in the population increased. 2

   This was to be expected if natural selection was changing the gene frequency of the peppered moth population. 1

   But the authors of the excerpt would need either another mutation to change black moths back to white, or mass migration of moths from non-industrial areas. 2

Excerpt B

4. Both light and dark moths were present in 1850 and 1950. 2

   The trees were light because they were encrusted with white lichens. 1

   No mutation was necessary in 1850. 1

   The change was in gene frequencies in the population. 1
5. Scientists studied a whole population, rather than a single mutant. 1

   Scientists made hypotheses, and tested them with experiments. 2

6. The reduction of soot in the air may make it possible for lichens to re-establish themselves on tree trunks. 1

The change in colour of the tree trunks will cause a change in selection pressure. 1

Birds will be able to see and eat more dark moths. 1

The frequency of the gene for darkness of colour will begin to decline in the population of moths. 1

Possible: 30

Maximum: 20

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B051SbSA.01
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 51Sb
UNIT NUMBER: 05	INSTRUMENT TYPE: SA
UNIT NAME: THEORY OF EVOLUTION	KLOPFER: A.1, A.3, A.9, E.2, E.3, I.3
	DIFFICULTY LEVEL: H
TOPIC: Geographical Isolation	TIME ALLOCATION:
CURRICULAR EMPHASIS: Communication	

KEYWORDS: Darwin

Guideline Objective

Students will have the opportunity to develop skill in abstracting information from reading selections on evolutionary theory and identifying the main ideas, the argument sequence, and the authors' points of view.

Item Focus

The student should be able to abstract evidence from Darwin's journal that led to his realization that species had changed.

Item

In 1831, the H. M. S. *Beagle*began a five-year voyage to chart in detail the coasts of South America and many oceanic islands. On board was a naturalist, Charles Darwin, whose task was to record the life forms and collect specimens wherever the ship stopped. Here are Darwin's observations of life on the opposite coasts of South America:

> "I was much struck with the marked difference between the vegetation of these Eastern valleys and those on the Chilian (Chilean) side: yet the climate, as well as the kind of soil, is nearly the same, and the difference in longitude very trifling. The same remark holds good with the quadrupeds, and in a lesser degree with the birds and insects. I may instance the mice, of which I obtained thirteen species on the shores of the Atlantic, and five on the Pacific, and not one of them is identical."

A. What conditions appeared to be the same on both coasts?

B. What forms of life differed between East and West coasts?

C. Why was Darwin impressed with his comparison?

D. Suggest a hypothesis to explain Darwin's observations.

Response/Marking Scheme

A.	climate, soil, longitude.	3
B.	vegetation, quadrupeds (e.g., mice), birds, insects.	4
C.	Darwin expected to find identical species occupying identical niches in different places.	2
	Yet his observations showed that different species were present in identical niches.	2
D.	Hypothesis: (any suitable hypothesis, such as) Geographical isolation, due to the mountains	2
	may have led to separate gene pools	1
	where many small mutations may have accumulated	1
	leading to new species.	1
	Possible:	16
	Maximum:	12

Teacher Notes

DRAFT

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 05
UNIT NAME: THEORY OF EVOLUTION

TOPIC: Speciation
CURRICULAR EMPHASIS: Communication

INSTRUMENT CODE: B051SbSA.02
GUIDELINE OBJECTIVE CODE: 51Sb 51Ka
INSTRUMENT TYPE: SA
KLOPFER: A.1, A.3, A.9, I.1, I.3, I.5
DIFFICULTY LEVEL: M
TIME ALLOCATION:

KEYWORDS: horse evolution

Guideline Objective

Students will have the opportunity to develop skill in abstracting information from reading selections on evolutionary theory and identifying the main ideas, the argument sequence, and the authors' points of view.

Item Focus

The student should be able to abstract the relevant ideas from two contrasting explanations of the fossil history of the horse family, and identify the authors' points of view.

Item

The following paragraphs are extracted from two high school biology texts. Both are explanations of the fossil history of the horse family. For each excerpt, express in your own words

A. three main ideas contained in the passage,

B. the point of view of the authors, and

C. the implication of the word "doctrine", used in the the first exerpt.

Excerpt 1, from *Biology: A Search for Order in Complexity:*

> There are at least twenty-six genera listed today. Furthermore, since all of these are considered as horses, then no biological changes exemplifying the doctrine of evolution (change of one form , or kind, into another) have been found. Consequently, so-called, horse evolution is actually no more than possible variation within describable limits of the horse form or kind. . .
>
> It may be that the size of some of the horse-like animals was caused by poor feed. It may be that side toes were lost through mutation. Some of the fossils probably represent genera not related to the horse. To claim that the horse increased in size and tooth structure at at the same time was undergoing extensive mutational losses is hardly positive genetics.
>
> There is only one way to determine whether or not varying organisms belong to the same species, and that is the attempt to breed the living organisms. Obviously this cannot be done with extinct organisms. The classification of fossil species is therefore more hypothetical than empirical (founded on evidence). There is no way to support the doctrine of evolution.

Excerpt 2, from *High School Biology:*

> At present, perhaps the most completely known fossil record of any evolutionary line is that of the horse family. The earliest organism that can be definitely identified as a member of the family was an Eocene animal scarcely larger than a fox terrier. . . There are many other differences between the Eocene and the modern horse.
>
> The fossil record shows that all these differences are the result of a series of gradual changes. The paleontologist George Gaylord Simpson has estimated that, during every period between the Eocene and the present, the populations of horses were so great that 150 000 *favorable* mutations of every gene involved in the evolutionary trend of each characteristic could have occurred! Each change that became established through natural selection must have been very slight; only when many such changes accumulated did they result in differences that can be detected. . . Thus one species was gradually transformed into a new species through the accumulation of genetic differences, and this happened many times in the horse family.

Response/Marking Scheme

	Exerpt 1 *Biology: A Search for*	Exerpt 2 *High School Biology*	
A. Three main ideas	1. Fossil horses represent variation within the horse "kind".	1. A very complete fossil record shows gradual changes.	2
	2. Small horses may have been the result of poor feed.	2. Populations were large enough for many favorable mutations to occur.	2
	3. Fossil organisms cannot be assigned to species since they can't be tested for interbreeding.	3. New species formed by the gradual accumulation of genetic differences.	2
B. Authors' point of view	There is no evidence for evolution among the horse family.	Evolution occurred by natural selection of many minor variations.	2

C. The word "doctrine" implies a religious teaching. 1

The authors are suggesting that evolution is a religious belief, rather than a scientific fact or theory. 1

Possible: 10

Maximum: 10

Teacher Notes

References: Taken from *Biology: A Search for Order in Complexity*, by John N. Moore and Harold Slusher. Copyright 1970, 1974 by the Zondervan Corporation, pp. 410. Used by permission.

BSCS, *High School Biology* (Chicago: Rand McNally & Co., 1963), pp. 593-5.

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 05
UNIT NAME: THEORY OF EVOLUTION

TOPIC: Population Genetics
CURRICULAR EMPHASIS: Nature of Science

INSTRUMENT CODE: B051ScLE.01
GUIDELINE OBJECTIVE CODE: 51Sc
INSTRUMENT TYPE: LE
KLOPFER: D.1, D.2, D.3, D.6
DIFFICULTY LEVEL: M
TIME ALLOCATION:

KEYWORDS: genetic drift gene frequencies

Guideline Objective

Students will have the opportunity to develop skill in using beads or other suitable materials to design models of a population genotype to show the effect of factors that may alter the genetic equilibrium of a population.

Item Focus

The student should be able to set up a model of a population that demonstrates genetic drift.

Item

Introduction:

In science, a model is often used when it is difficult to observe a principle in action. Change of a population of real organisms over many generations can be simulated. In this model, beads represent individuals in a population. A particular trait in this population has two alleles, represented in the model by two colours, red and blue. An opaque bag allows you to sample the population randomly by reaching in without seeing the colour of the beads.

Materials:

25 red beads

25 blue beads

1 opaque bag, large enough to hold all the beads

2 beakers

Method:

1. Set up a model of a population of a diploid organism, using 25 red beads and 25 blue beads. The two colours represent the two alleles of a particular trait.

2. Place the entire population into a bag.

3. Assume that ten individuals from this population migrate to a new location. Randomly withdraw their genes from the bag, and place them into a beaker.

4. Record the gene constitution of the new population.

5. Compare the gene frequencies of the new population with those of the original population.

6. Repeat this step three times. How did the average of the results differ?

7. Now place the genes of the original population aside in a beaker. Put into the bag the genes of the 10 individuals of your first migrant population. Assume that only 6 of these individuals succeed in reproducing successfully (3 males, 3 females) to form the next generation, and that each pair produces 2 offspring.

8. Randomly draw the genes of the parents from the bag, and record them.

9. Show the possible gene frequencies of the offspring, and compare them with those of their parents. How do they differ from the original population?

10. What effect have you demonstrated?

11. What are the implications of this principle on actual populations in nature?

Response/Marking Scheme

The student will	
make an appropriate table for recording	1
withdraw exactly 20 genes to represent the migrants	1
record the number of each kind of genes in the migrant population	1
calculate the percentage of each allele	1
compare the percentage in the migrant population with the 50% : 50% gene frequency	1
repeat 3 times, recording figures for each try	1
calculate the average of the 4 migrations	1
set up the first migrant population as directed	1
record the gene constitutions of the 6 parents	2
show the possible gene constitutions of the 6 offspring	6
make a statement comparing offspring with parents	2
calculate the change from the original population	2
name the process: genetic drift	1
explain how genetic drift may contribute to speciation.	2
Possible:	23
Maximum:	20

Teacher Notes

Since real evolution takes a long time, models are often used to illustrate a principle. This is a required activity in the 1987 guidelines. Make a decision about the materials available, and amend the instrument accordingly.

Materials:

25 red beads (or beans, poker chips, cardboard squares)

25 blue beads (or substitute as above)

1 opaque bag, large enough to hold all the beads

2 beakers

Safety Precautions:

none

DRAFT

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B051KaMC.01
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 51Ka
UNIT NUMBER: 05	INSTRUMENT TYPE: MC
UNIT NAME: THEORY OF EVOLUTION	KLOPFER: A.1, A.2, A.3
	DIFFICULTY LEVEL: M
TOPIC: Paleontology	TIME ALLOCATION:
CURRICULAR EMPHASIS: Solid Foundations	

KEYWORDS: species niches dinosaur

Guideline Objective

Students will be expected to name and briefly describe the lines of evidence from areas of biology which support and are explained by the theory of evolution, i.e. evidence from paleontology, comparative anatomy (homologous and analagous structures), embryology, comparative biochemistry, selective breeding and the geographical distribution of species.

Item Focus

The student should be able to recognize that the principles of ecology applied in pre-historic times.

Item

The fossil record shows that dinosaurs existed in great numbers and many different forms. From a scientific viewpoint, the most reasonable conclusion is that

☐ A. this was the reason for their respective extinctions.

☐ B. the many different species occupied many different ecological niches.

☐ C. they never became very specialized.

☐ D. they were the direct ancestors of animals that occupy the various niches today.

☐ E. they were resistant to diseases.

Response/Marking Scheme

Correct response: B

Teacher Notes

DRAFT

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B051KaMC.02
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 51Ka
UNIT NUMBER: 05	INSTRUMENT TYPE: MC
UNIT NAME: THEORY OF EVOLUTION	KLOPFER: A.1, A.2, A.3, A.5, A.7
	DIFFICULTY LEVEL: M
TOPIC: Paleontology	TIME ALLOCATION:
CURRICULAR EMPHASIS: Nature of Science	

KEYWORDS: radioactive dating uranium fossils graphical analysis

Guideline Objective

Students will be expected to name and briefly describe the lines of evidence from areas of biology which support and are explained by the theory of evolution, i.e. evidence from paleontology, comparative anatomy (homologous and analagous structures), embryology, comparative biochemistry, selective breeding and the geographical distribution of species.

Item Focus

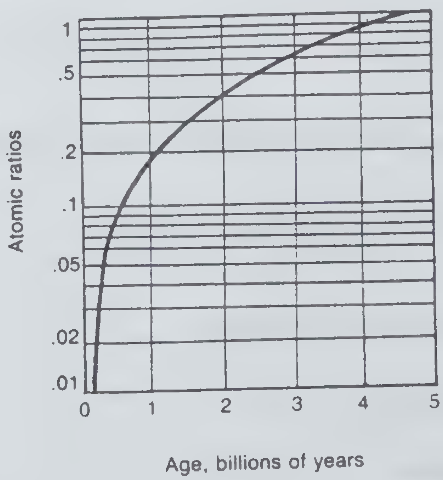
The student should be able to determine the age of a rock stratum given a chart of atomic ratios of lead to uranium versus time.

Item

Fossils are often dated by determining the age of the strata of sedimentary rock in which it was found. A rock sample in which a fossil was found contained a ratio of 1 part lead to 4 parts uranium. Using the chart below, determine the approximate age of the fossil.

- ☐ A. 2 billion years old
- ☐ B. 250 million years old
- ☐ C. 1.5 billion years old
- ☐ D. 4 billion years old
- ☐ E. 0.2 billion years old

RATIO OF LEAD TO URANIUM IN ROCK OVER TIME



Response/Marking Scheme

Correct response: C

Teacher Notes

DRAFT

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B051KaMC.03
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 51Ka
UNIT NUMBER: 05	INSTRUMENT TYPE: MC
UNIT NAME: THEORY OF EVOLUTION	KLOPFER: A.1, A.2, A.3, A.5
	DIFFICULTY LEVEL: M
TOPIC: Paleontology	TIME ALLOCATION:
CURRICULAR EMPHASIS: Solid Foundations	

KEYWORDS: extinction selection pressure

Guideline Objective

Students will be expected to name and briefly describe the lines of evidence from areas of biology which support and are explained by the theory of evolution, i.e. evidence from paleontology, comparative anatomy (homologous and analogous structures), embryology, comparative biochemistry, selective breeding and the geographical distribution of species.

Item Focus

The student should be able to identify the effects of extinction on the evolution of life.

Item

One of the features of the paleontological record is extinction. Geological eras and epochs are marked off by intervals when as many as 50% of the known families of organisms became extinct. Over 99% of all past phyletic lines are now extinct.

All but one of the following statements are logical hypotheses about the effects of extinction on the evolution of life. Which one is **NOT**?

☐ A. Following each extinction there were a number of empty niches, into which surviving organisms diversified.

☐ B. At the end of each geological period, a major catastrophe wiped out all the life forms and new life appeared.

☐ C. The changing environment selected the organisms best adapted.

☐ D. Species were not always capable of adapting to new selection pressures.

☐ E. Extinction removed the species least adapted to changing environmental conditions.

Response/Marking Scheme

Correct response: B

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B051KaMC.04
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 51Ka
UNIT NUMBER: 05	INSTRUMENT TYPE: MC
UNIT NAME: THEORY OF EVOLUTION	KLOPFER: A.1, A.2, A.3, A.5
	DIFFICULTY LEVEL: L
TOPIC: Pattern of Descent	TIME ALLOCATION:
CURRICULAR EMPHASIS: Solid Foundations	

KEYWORDS: paleontology

Guideline Objective

Students will be expected to name and briefly describe the lines of evidence from areas of biology which support and are explained by the theory of evolution, i.e. evidence from paleontology, comparative anatomy (homologous and analogous structures), embryology, comparative biochemistry, selective breeding and the geographical distribution of species.

Item Focus

The student should be able to identify the pattern of ascent of an evolutionary tree.

Item

Evidence from paleontology suggests that the pattern of ascent of an organism from its ancestors resembles a

☐ A. pyramid

☐ B. branching bush

☐ C. ladder

☐ D. straight line

☐ E. spiral

Response/Marking Scheme

Correct response: B

Teacher Notes

DRAFT

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B051KaMC.05
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 51Ka
UNIT NUMBER: 05	INSTRUMENT TYPE: MC
UNIT NAME: THEORY OF EVOLUTION	KLOPFER: A.1, A.2, A.3, A.5
	DIFFICULTY LEVEL: L
TOPIC: Comparative Embryology	TIME ALLOCATION:
CURRICULAR EMPHASIS: Solid Foundations	

KEYWORDS: gill slits

Guideline Objective

Students will be expected to name and briefly describe the lines of evidence from areas of biology which support and are explained by the theory of evolution, i.e. evidence from paleontology, comparative anatomy (homologous and analogous structures), embryology, comparative biochemistry, selective breeding and the geographical distribution of species.

Item Focus

The student should be able to identify the likely significance of common structures of chordate embryos.

Item

The appearance of structures that resemble gill slits in the early embryonic development of all chordates is usually accepted as evidence that

☐ A. developing mammalian embryos, surrounded by embryonic fluids, breathe by means of gills.

☐ B. fish, amphibia, reptiles, birds and mammals are probably descended from a common ancestor.

☐ C. vestigial structures have a function in early embryonic development.

☐ D. the origin of life can be traced by means of the theory of evolution.

☐ E. gill slits serve only as the substructures for later development of the tissues and organs of the neck.

Response/Marking Scheme

Correct response: B

Teacher Notes

DRAFT

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B051KaMC.06
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 51Ka
UNIT NUMBER: 05	INSTRUMENT TYPE: MC
UNIT NAME: THEORY OF EVOLUTION	KLOPFER: A.1, A.2, A.3, A.5
	DIFFICULTY LEVEL: L
TOPIC: Comparative Anatomy	TIME ALLOCATION:
CURRICULAR EMPHASIS: Solid Foundations	

KEYWORDS: vestigial organ

Guideline Objective

Students will be expected to name and briefly describe the lines of evidence from areas of biology which support and are explained by the theory of evolution, i.e. evidence from paleontology, comparative anatomy (homologous and analogous structures), embryology, comparative biochemistry, selective breeding and the geographical distribution of species.

Item Focus

The student should be able to identify the nature of a vestigial organ.

Item

A vestigial organ is one that is

☐ A. in the process of developing into a useful organ.

☐ B. of great physiological importance.

☐ C. reduced in form and in function.

☐ D. found only in the embryo.

☐ E. peripherally located.

Response/Marking Scheme

Correct response: C

Teacher Notes

DRAFT

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 05
UNIT NAME: THEORY OF EVOLUTION

TOPIC: The Modern Theory
CURRICULAR EMPHASIS: Nature of Science

INSTRUMENT CODE: B051KaMC.07
GUIDELINE OBJECTIVE CODE: 51Ka
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3, A.5
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: karyotype

Guideline Objective

Students will be expected to name and briefly describe the lines of evidence from areas of biology which support and are explained by the theory of evolution, i.e. evidence from paleontology, comparative anatomy (homologous and analogous structures), embryology, comparative biochemistry, selective breeding and the geographical distribution of species.

Item Focus

The student should be able to identify the significance of similar karyotypes among primates.

Item

Humans normally have 46 chromosomes, while chimpanzees, gorillas, and orangutans have 48 chromosomes. Karyotypes of the four species show striking similarities. The best explanation of these facts is that

☐ A. convergent evolution has created similar chromosomes.

☐ B. divergent evolution has made the chromosomes similar.

☐ C. the environment has shaped each organism to fit a different niche.

☐ D. the four species are likely descended from a common ancestor.

☐ E. the four species are likely descended from two common ancestors.

Response/Marking Scheme

Correct response: D

Teacher Notes

DRAFT

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 05
UNIT NAME: THEORY OF EVOLUTION

TOPIC: Comparative Biochemistry
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B051KaMC.08
GUIDELINE OBJECTIVE CODE: 51Ka
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3, A.5
DIFFICULTY LEVEL: M
TIME ALLOCATION:

KEYWORDS: proteins genetic code

Guideline Objective

Students will be expected to name and briefly describe the lines of evidence from areas of biology which support and are explained by the theory of evolution, i.e. evidence from paleontology, comparative anatomy (homologous and analogous structures), embryology, comparative biochemistry, selective breeding and the geographical distribution of species.

Item Focus

The student should be able to identify the form in which the history of genetic change is recorded in protein molecules.

Item

The following statement, written by E. Zuckerkandl in an article "The Evolution of Hemoglobin," appeared in *Scientific American*, May, 1965:

> "Every living thing carries within itself a richly detailed record of its antecedents from the beginning of life on earth. This record is preserved in coded form in the giant molecules of deoxyribonucleic acid (DNA). . . The genetic record is also expressed more tangibly in the protein molecules that endow the organism with its form and function."

In what form is the genetic record expressed in protein molecules?

☐ A. Nucleotide bases occur in particular sequences that vary from one species to another.

☐ B. All living organisms make their own specific kinds of protein from the same kinds of amino acids.

☐ C. The sequence and number of amino acids in a particular protein differ only slightly among related species.

☐ D. The ribosomes assemble the different proteins according to specifications carried by the messenger RNA molecules.

☐ E. The sequence and numbers of the pairs of nucleotide bases in a particular chromosome differ slightly from species to species.

Response/Marking Scheme

Correct response: C

Teacher Notes

DRAFT

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 05
UNIT NAME: THEORY OF EVOLUTION

TOPIC: Comparative Biochemistry
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B051KaMC.09
GUIDELINE OBJECTIVE CODE: 51Ka
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3, A.5
DIFFICULTY LEVEL: M
TIME ALLOCATION:

KEYWORDS: proteins phylogenetic tree genetic code

Guideline Objective

Students will be expected to name and briefly describe the lines of evidence from areas of biology which support and are explained by the theory of evolution, i.e. evidence from paleontology, comparative anatomy (homologous and analogous structures), embryology, comparative biochemistry, selective breeding and the geographical distribution of species.

Item Focus

The student should be able to identify the assumptions that scientists would make in constructing a phylogenetic tree based on differences in protein structure.

Item

The following statement, written by E. Zuckkandl in an article "The Evolution of Hemoglobin" appeared in *Scientific American*, May, 1965:

> "Every living thing carries within itself a richly detailed record of its antecedents from the beginning of life on earth. This record is preserved in coded form in the giant molecules of deoxyribonucleic acid (DNA). . . The genetic record is also expressed more tangibly in the protein molecules that endow the organism with its form and function."

Which one of the following statements would scientists likely make as they constructed a phylogenetic tree based on differences in protein structure?

☐ A. Species with fewer differences in the structure of a particular protein are considered to have branched more recently from a common ancestor, and thus to be more closely related than those with more differences.

☐ B. Species with more differences in the structure of a particular protein are considered to have branched more recently from a common ancestor, and thus to be more closely related than those with fewer differences.

☐ C. Scientists would separate each protein chemically into its components, and then assemble them to make the phylogenetic tree.

☐ D. All the amino acids of the same type are extracted from several different proteins from different species, and the differences counted to make a diagramatic tree of relationships.

☐ E. Species with fewer differences in the structure of a particular protein are considered to have branched longer ago from a common ancestor, and thus to be more distantly related than those with more differences.

Response/Marking Scheme

Correct response: A

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 05
UNIT NAME: THEORY OF EVOLUTION

TOPIC: Homology
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B051KaMC.10
GUIDELINE OBJECTIVE CODE: 51Ka
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3, A.5
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: embryonic origin

Guideline Objective

Students will be expected to name and briefly describe the lines of evidence from areas of biology which support and are explained by the theory of evolution, i.e. evidence from paleontology, comparative anatomy (homologous and analogous structures), embryology, comparative biochemistry, selective breeding and the geographical distribution of species.

Item Focus

The student should be able to identify the characteristics of homologous structures.

Item

Which one of the following statements is the best description of homologous structures?

They have a similar

☐ A. structure but a different embryonic origin.

☐ B. function but no common ancestry.

☐ C. structure and embryonic origin.

☐ D. function but a different structure.

☐ E. appearance and embryonic origin.

Response/Marking Scheme

Correct response: C

Teacher Notes

DRAFT

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B051KaMC.11
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 51Ka
UNIT NUMBER: 05	INSTRUMENT TYPE: MC
UNIT NAME: THEORY OF EVOLUTION	KLOPFER: A.1, A.2, A.3, A.9, A.10
	DIFFICULTY LEVEL: L
TOPIC: Comparative Anatomy	TIME ALLOCATION:
CURRICULAR EMPHASIS: Solid Foundations	

KEYWORDS: homology

Guideline Objective

Students will be expected to name and briefly describe the lines of evidence from areas of biology which support and are explained by the theory of evolution, i.e. evidence from paleontology, comparative anatomy (homologous and analogous structures), embryology, comparative biochemistry, selective breeding and the geographical distribution of species.

Item Focus

The student should be able to distinguish between different kinds of evidence for evolution.

Item

Refer to Figure 5K.1.

BONES OF THE FORELIMBS OF FOUR VERTEBRATES

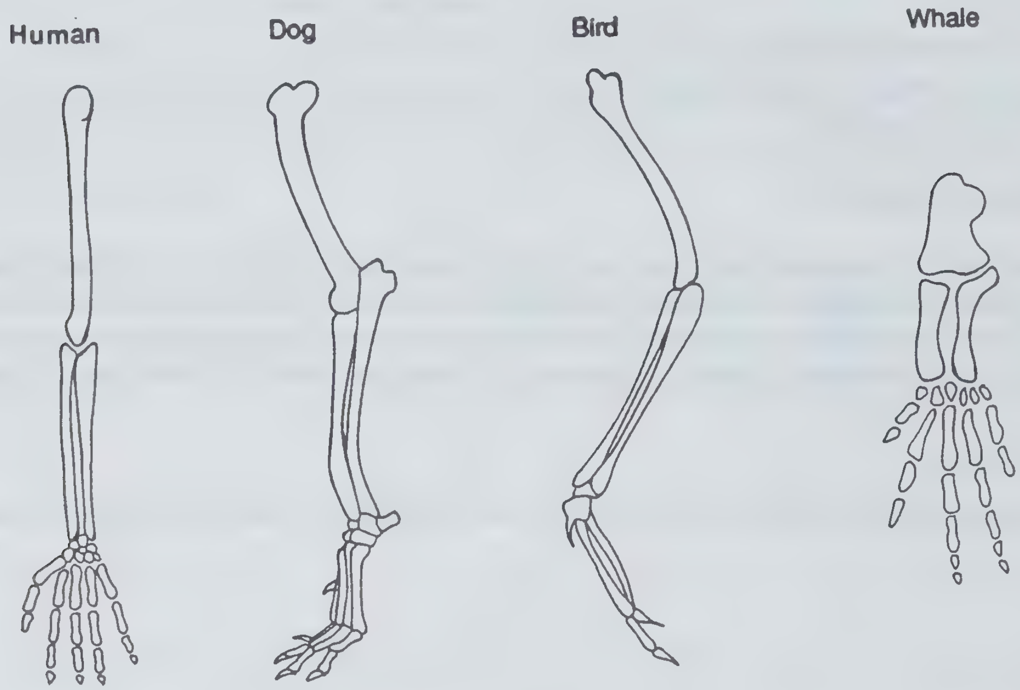


Figure 5K.1 illustrates one kind of evidence for the process of evolution. The kind of relationship shown is

- ☐ A. analogy.
- ☐ B. homology.
- ☐ C. mutation.
- ☐ D. fossils.
- ☐ E. vestigial structures.

Response/Marking Scheme

Correct response: B

DRAFT

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B051KaMC.12
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 51Ka
UNIT NUMBER: 05	INSTRUMENT TYPE: MC
UNIT NAME: THEORY OF EVOLUTION	KLOPFER: A.1, A.2, A.3
	DIFFICULTY LEVEL: L
TOPIC: Adaptive Radiation	TIME ALLOCATION:
CURRICULAR EMPHASIS: Solid Foundations	

KEYWORDS: descent

Guideline Objective

Students will be expected to name and briefly describe the lines of evidence from areas of biology which support and are explained by the theory of evolution, i.e. evidence from paleontology, comparative anatomy (homologous and analogous structures), embryology, comparative biochemistry, selective breeding and the geographical distribution of species.

Item Focus

The student should be able to identify concepts involved in the evidence for the theory of evolution.

Item

The concept of adaptive radiation implies that

☐ A. two or more lines of descent have evolved from a common ancestor.

☐ B. humans have descended from the apes.

☐ C. all animal groups arose directly from one ancestral type.

☐ D. all well-adapted forms in evolutionary history have survived.

☐ E. only the most fit species have survived.

Response/Marking Scheme

Correct response: A

Teacher Notes

DRAFT

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B051KaMC.13
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 51Ka
UNIT NUMBER: 05	INSTRUMENT TYPE: MC
UNIT NAME: THEORY OF EVOLUTION	KLOPFER: A.1, A.2, A.3, A.8, I.3
	DIFFICULTY LEVEL: M
TOPIC: Peppered Moth	TIME ALLOCATION:
CURRICULAR EMPHASIS: Nature of Science	

KEYWORDS: Kettlewell

Guideline Objective

Students will be expected to name and briefly describe the lines of evidence from areas of biology which support and are explained by the theory of evolution, i.e. evidence from paleontology, comparative anatomy (homologous and analogous structures), embryology, comparative biochemistry, selective breeding and the geographical distribution of species.

Item Focus

The student should be able to identify the assumption in which Kettlewell's experiment is based.

Item

In Kettlewell's experiment,in the 1950's, a large number of dark and light forms of peppered moths were captured and marked for identification. He released 488 dark moths and 496 light moths into a forest. After three days, 34 dark moths and 62 light moths were recaptured.

Which of the following is the most reasonable assumption?

- ☐ A. The moths were released in a forest with mostly dark tree trunks.
- ☐ B. The traps were placed in locations where more light moths gather.
- ☐ C. More light moths were recaptured because predators ate more dark moths.
- ☐ D. The recaptured moths were too few in number to draw a conclusion.
- ☐ E. More light moths were captured because they are more attracted to the traps than dark moths.

Response/Marking Scheme

Correct response: C

DRAFT

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B051KaMC.14
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 51Ka
UNIT NUMBER: 05	INSTRUMENT TYPE: MC
UNIT NAME: THEORY OF EVOLUTION	KLOPFER: A.1, A.2, A.3
	DIFFICULTY LEVEL: L
TOPIC: Natural Selection	TIME ALLOCATION:
CURRICULAR EMPHASIS: Solid Foundations	

KEYWORDS: peppered moth Kettlewell

Guideline Objective

Students will be expected to name and briefly describe the lines of evidence from areas of biology which support and are explained by the theory of evolution, i.e. evidence from paleontology, comparative anatomy (homologous and analogous structures), embryology, comparative biochemistry, selective breeding and the geographical distribution of species.

Item Focus

The student should be able to identify the hypothetical reason for the change in the population of peppered moths.

Item

In industrial regions, many moths have both dark and light forms, but the dark forms have been increasing. The increase in frequency of the dark form of peppered moths is thought to depend on

☐ A. the dark forms being more difficult for birds to detect.

☐ B. the light forms being well camouflaged against lichen-covered trees.

☐ C. the birds avoiding the dark forms because of their taste.

☐ D. the birds being unable to detect the light forms.

☐ E. the moths resembling other species that are unpalatable to birds (mimicry).

Response/Marking Scheme

Correct response: A

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 05
UNIT NAME: THEORY OF EVOLUTION

TOPIC: Variation in Populations
CURRICULAR EMPHASIS: Nature of Science

INSTRUMENT CODE: B051KaMC.15
GUIDELINE OBJECTIVE CODE: 51Ka
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: Kettlewell peppered moth

Guideline Objective

Students will be expected to name and briefly describe the lines of evidence from areas of biology which support and are explained by the theory of evolution, i.e. evidence from paleontology, comparative anatomy (homologous and analogous structures), embryology, comparative biochemistry, selective breeding and the geographical distribution of species.

Item Focus

The student should be able to identify the concept of natural selection in the example of peppered moths.

Item

Kettlewell's studies of peppered moths provided evidence that indicated

☐ A. support for the Hardy-Weinberg law.

☐ B. that dominant genes will eventually replace their recessive alleles.

☐ C. that light and dark moths differ in their ability to survive on light and dark backgrounds.

☐ D. that dark moths evolved from white moths.

☐ E. that individual moths can change because of environmental pressures.

Response/Marking Scheme

Correct response: C

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B051KaMC.16
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 51Ka
UNIT NUMBER: 05	INSTRUMENT TYPE: MC
UNIT NAME: THEORY OF EVOLUTION	KLOPFER: A.1, A.2, A.3, A.10, D.5
	DIFFICULTY LEVEL: L
TOPIC: Natural Selection	TIME ALLOCATION:
CURRICULAR EMPHASIS: Nature of Science	

KEYWORDS: Kettlewell peppered moths

Guideline Objective

Students will be expected to name and briefly describe the lines of evidence from areas of biology which support and are explained by the theory of evolution, i.e. evidence from paleontology, comparative anatomy (homologous and analogous structures), embryology, comparative biochemistry, selective breeding and the geographical distribution of species.

Item Focus

The student should be able to identify a likely hypothesis to account for new evidence.

Item

In a follow-up to Kettlewell's experiments on natural selection among peppered moths, it was discovered that the gene for dark colour (melanism) is dominant, and that homozygous and heterozygous individuals having the melanic gene look exactly alike.

When equal numbers of heterozygotes and homozygotes were released in a woodland near an industrial city, significantly more heterozygotes than homozygotes were recovered a few days later. Which of the following hypotheses best explains the different recovery rates?

☐ A. Homozygotes are less fertile than heterozygotes.

☐ B. Birds can see homozygotes more readily than they can see heterozygotes.

☐ C. Homozygotes spontaneously change into heterozygotes.

☐ D. The scientists released fewer homozygotes than heterozygotes.

☐ E. Heterozygotes have a physiological advantage over homozygotes.

Response/Marking Scheme

Correct response: E

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B051KaMC.17
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 51Ka
UNIT NUMBER: 05	INSTRUMENT TYPE: MC
UNIT NAME: THEORY OF EVOLUTION	KLOPFER: A.1, A.3, A.8, I.3
	DIFFICULTY LEVEL: L
TOPIC: Peppered Moth	TIME ALLOCATION:
CURRICULAR EMPHASIS: Nature of Science	

KEYWORDS: Kettlewell

Guideline Objective

Students will be expected to name and briefly describe the lines of evidence from areas of biology which support and are explained by the theory of evolution, i.e. evidence from paleontology, comparative anatomy (homologous and analogous structures), embryology, comparative biochemistry, selective breeding and the geographical distribution of species.

Item Focus

The student should be able to identify the nature of the data Kettlewell collected.

Item

In Kettlewell's experiment, in the 1950's, a large number of dark and light forms of moths were captured and marked for identification. He released 488 dark moths and 496 light moths back into their forest environment. After three days he captured 34 dark moths and 62 light moths.

Kettlewell's experiment on moth populations provides data on

I the effect of environment on survival of favourable variations.

II reproduction as a factor in maintaining populations of organisms.

III the survival rate of moths in a forest environment.

IV the ability of a species to exist in an unnatural environment.

V the rate at which moths are caught in a trap.

Select your response from:

☐ A. I and II

☐ B. II and III

☐ C. I and III

☐ D. II and IV

☐ E. I and V

Response/Marking Scheme

Correct response: C

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 05
UNIT NAME: THEORY OF EVOLUTION

TOPIC: Paleontology
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B051KaER.01
GUIDELINE OBJECTIVE CODE: 51Ka
INSTRUMENT TYPE: ER
KLOPFER: A.1, A.2, A.3, A.5
DIFFICULTY LEVEL: M
TIME ALLOCATION:

KEYWORDS: horse evolution.

Guideline Objective

Students will be expected to name and briefly describe the lines of evidence from areas of biology which support and are explained by the theory of evolution, i.e. evidence from paleontology, comparative anatomy (homologous and analogous structures), embryology, comparative biochemistry, selective breeding and the geographical distribution of species.

Item Focus

The student should be able to describe the paleontological evidence for the evolution of horses, and explain the developments in terms of adaptations for survival.

Item

One of the well documented evolutionary lineages is that of the horse. Describe three major structural changes that occurred in the evolution of horses, and explain why each of these would have had adaptive value.

Response/Marking Scheme

Over 60×10^6 a, horses changed from small animals that browsed on leaves in the forests to large animals that grazed the plains.

STRUCTURAL CHANGES		ADAPTIVE VALUE	
The feet: changed from 5 toes to 3 toes to 1 toe with hoof.	2	Adaptation for running across the plains, as a drier climate caused forests to change to grasslands.	2
The teeth: changed from small with few cusps to large, evergrowing, with intricate grinding surfaces.	2	Adaptation for biting off and chewing grass, which is tough because of silica walls, wearing teeth down.	2
The skull: grew longer, with eye sockets moving towards the rear, facing out to see 180° in each direction.	2	Eyes could watch for predators above the grass, ready to alert the horses to run.	2

Possible: 12

Maximum: 12

Teacher Notes

DRAFT

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B051KaER.02
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 51Ka
UNIT NUMBER: 05	INSTRUMENT TYPE: ER
UNIT NAME: THEORY OF EVOLUTION	KLOPFER: A.1, A.2, A.3, A.8, A.9
	DIFFICULTY LEVEL: L
TOPIC: Modern Theory of Evolution	TIME ALLOCATION:
CURRICULAR EMPHASIS: Solid Foundations	

KEYWORDS: phylogenetic tree

Guideline Objective

Students will be expected to name and briefly describe the lines of evidence from areas of biology which support and are explained by the theory of evolution, i.e. evidence from paleontology, comparative anatomy (homologous and analogous structures), embryology, comparative biochemistry, selective breeding and the geographical distribution of species.

Item Focus

The student should be able to criticize a linear pattern of the evolution of life, and describe the history of life as a branching tree.

Item

Sometimes, the evolution of life is represented as shown below. Criticize this representation, and describe or illustrate a more scientifically acceptable view.

PROTOZOANS ⟶ SPONGES ⟶ COELENTERATES ⟶ WORMS ⟶ ARTHROPODS ⟶ FISHES ⟶ AMPHIBIANS ⟶ REPTILES ⟶ BIRDS ⟶ MAMMALS ⟶ HUMANS

Response/Marking Scheme

The scheme is a linear sequence of events, in which each	1
"higher" (more complex) type evolves from a "lower" (less complex) type.	1
In fact, each species now living is highly evolved	1
and as complex in organization as it needs to be to succeed in its niche, in competition with other species.	2
There are errors: there is no evidence that vertebrates evolved from arthropods. Evidence indicates that mammals arose from reptiles, not from birds.	1
The scheme should show a tree-like arrangement, with many	1
diverging branches reaching the present time.	1

<u>OR</u>

Accept a simple, labelled tree sketch.	2
Possible:	8
Maximum:	6

Teacher Notes

DRAFT

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 05
UNIT NAME: THEORY OF EVOLUTION

TOPIC: Distribution of Life
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B051KaER.03
GUIDELINE OBJECTIVE CODE: 51Ka
INSTRUMENT TYPE: ER
KLOPFER: A.1, A.2, A.3, A.9, D.3
DIFFICULTY LEVEL: M
TIME ALLOCATION:

KEYWORDS: fossil record

Guideline Objective

Students will be expected to name and briefly describe the lines of evidence from areas of biology which support and are explained by the theory of evolution, i.e. evidence from paleontology, comparative anatomy (homologous and analogous structures), embryology, comparative biochemistry, selective breeding and the geographical distribution of species.

Item Focus

Same as above.

Item

The table below represents paleontologist G. G. Simpson's compilation of evidence from the fossil records of the continents of North and South America.

FAMILIES OF LAND MAMMALS*

	In North America		In South America	
Epoch	Native	South American	Native	North American
Recent	20	3	16	14
Pleistocene	26	8	23	13
Mid-Pliocene	26	1	24	1
Mid-Miocene	27	0	23	0

A. Suggest an hypothesis to explain the zeros in the bottom line of the table.

B. During the Pliocene epoch that followed, a family of rodents and a family of monkeys were able to migrate from one continent to the other. Hypothesize about the change in geographical conditions that would have permitted such movement while restricting other groups of land animals from migrating.

C. Account for the movements of the Pleistocene and Recent epochs. What became of the native families when the newcomers arrived? Explain why this might have happened.

Response/Marking Scheme

A. The continents were separated by an ocean that formed a barrier to the movement of land mammals. 2

B. Perhaps a line of volcanic islands, such as the West Indies, reduced the oceanic barrier so that two species were successful in swimming from island to island. 2

C. During the Pleistocene, more families were able to move each way. Probably the Central American connection between the continents formed a land bridge by this time. 2

More families moved from North America than from South America. 1

On both continents, the number of indigenous families declined. Perhaps they now had more competition in the same niches and were unable to compete successfully. 2

Perhaps many of the newcomers were predators that found and eliminated their new prey. 2

Possible: 11

Maximum: 8

*George Gaylord Simpson. *Evolution and Geography*, Oregon State System of Higher Education, 1953 Condon Lectures, p. 27.

Teacher Notes

DRAFT

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B051KaER.04
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 51Ka
UNIT NUMBER: 05	INSTRUMENT TYPE: ER
UNIT NAME: THEORY OF EVOLUTION	KLOPFER: A.1, A.2, A.3, A.6.
	DIFFICULTY LEVEL: H
TOPIC: Paleontology	TIME ALLOCATION:
CURRICULAR EMPHASIS: Nature of Science	

KEYWORDS: *Archaeopteryx* comparative anatomy

Guideline Objective

Students will be expected to name and briefly describe the lines of evidence from areas of biology which support and are explained by the theory of evolution, i.e. evidence from paleontology, comparative anatomy (homologous and analogous structures), embryology, comparative biochemistry, selective breeding and the geographical distribution of species.

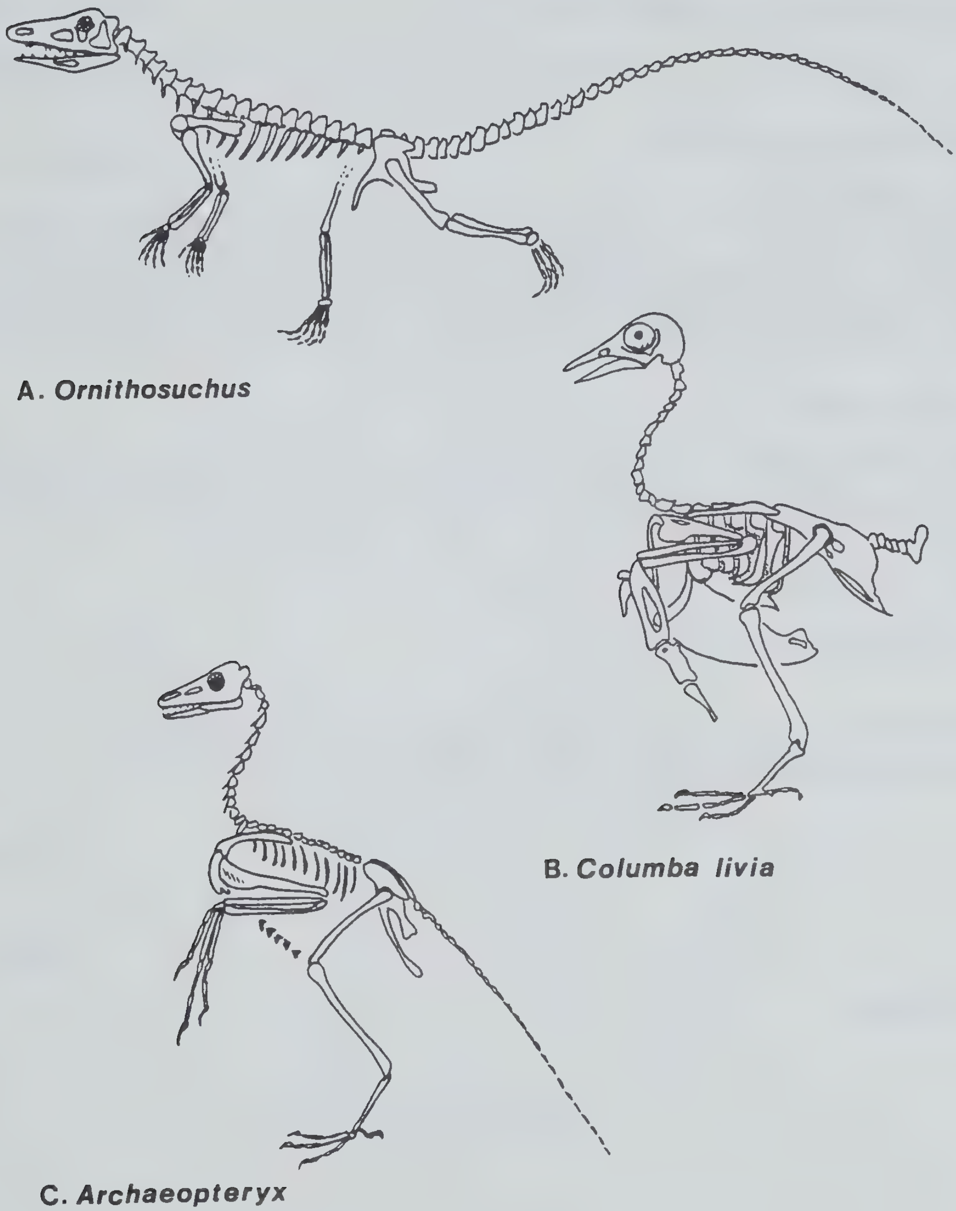
Item Focus

The student should be able to evaluate the position of a fossil skeleton by comparative anatomy.

Item

Refer to Figure 5K.2.

SKELETONS OF (A) *Ornithosuchus*, A STEM REPTILE FROM **THE TRIASSIC PERIOD, (B) A PIGEON,** *Columba livia*, **AND (C)** *Archaeopteryx*, FROM THE JURASSIC PERIOD



Six specimens of *Archaeopteryx* were preserved in the fine limestone of Bavaria. The impression of feathers was preserved along with the skeletons.

A. List five features of the skeleton of *Archaeopteryx* that are similar to those of the stem reptile, *Ornithosuchus*.

B. List five features of the skeleton of *Archaeopteryx* that are similar to those of a modern bird.

C. Evaluate the position of *Archaeopteryx* in the taxonomy of vertebrates. Should it be classified as a bird, as a reptile, or as an intermediate between birds and reptiles? Support your opinion with reasons.

Response/Marking Scheme

A. teeth present
breastbone small and slight
many separate ribs
separate hip bones
long tail of many separate vertebrae
claws of digits of fore limb (any 5) 5

B. thin, light skull
long, flexible neck
similar shoulder girdle
long forelimb with fewer digits
hip braced to many vertebrae, slender
long hind limb with 4 clawed toes (any 5) 5

C. *Archaeopteryx* appears to be intermediate between reptiles and birds because it shares many of the features of each. 2

Possible: 12

Maximum: 12

Teacher Notes

DRAFT

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 05
UNIT NAME: THEORY OF EVOLUTION

TOPIC: Modern Theory
CURRICULAR EMPHASIS: Nature of Science

INSTRUMENT CODE: B051KaER.05
GUIDELINE OBJECTIVE CODE: 51Ka
INSTRUMENT TYPE: ER
KLOPFER: A.1, A.2, A.3, A.9
DIFFICULTY LEVEL: H
TIME ALLOCATION:

KEYWORDS: continental drift plate tectonics

Guideline Objective

Students will be expected to name and briefly describe the lines of evidence from areas of biology which support and are explained by the theory of evolution, i.e. evidence from paleontology, comparative anatomy (homologous and analogous structures), embryology, comparative biochemistry, selective breeding and the geographical distribution of species.

Item Focus

The student should be able to correlate evidence from geology and biology to synthesize the effect of continental drift on the origin and distribution of groups of mammals.

Item

Refer to Figure 5K.3.

RECONSTRUCTION OF THE POSITIONS OF THE CONTINENTS AT TIMES IN THE EARTH'S PAST

Early Mesozoic

Late Mesozoic

The Theory of Continental Drift suggests that the surface of our planet consists of plates of crust that float on deeper, molten material. Figure 5K.3 represents reconstructions of the geography of our planet at certain times in the past. Geological and paleontological evidence suggests that Australia was part of Gondwana, along with Africa, Antarctica, India, and South America during the Mesozoic ("The Age of Reptiles"), 135 000 000 years ago, but has been separated from other land masses ever since. South America is thought to have separated from Africa 65 000 000 years ago, when the Atlantic Ocean began to open, and remained on its own until it came into contact with Central America 3 000 000 years ago.

There are three quite different sub-orders of mammals:

Monotremes	- egg laying platypus and spiny anteater, presentlyoccurring only in Australia, but fossil evidence showing that they formerly lived on several continents;
Marsupials	- pouched mammals, in which the early embryo, after a short gestation, emerges from the uterus and climbs into the pouch to complete its development: wallabies, and kangaroos and many other families occurring only in Australia; opossums in North America; and two species occurring in South America; A marsupial mouse has been found frozen in the permafrost of Antarctica.
Placentals	- with a complete intra-uterine development, occurring naturally on every land mass but Australia, where there were only a few species of bats and rodents.

A. Explain why monotremes occur only in Australia.

B. Explain why marsupials occur mainly in Australia, and why there are some marsupials in North and South America.

C. Explain why placentals (with a very few exceptions) did not occur in Australia, but populated every other land mass.

Response/Marking Scheme

A. Monotremes were likely the first mammals to evolve from a reptilian ancestor. 1

They developed as Australia separated from other land masses, as an isolated gene pool. 1

The monotremes were unable to spread to other lands because the sea was too great a barrier. 1

If monotremes were present on other continents, they were exterminated by competition or predation. 1

B. Marsupials may have evolved from a similar reptilian stock as the monotremes. 1

Before Australia separated from other continents, early species must have entered from South America. 1

When S. America joined central America, the opossum would have migrated north into N. America. 1

During the long period when Australia was on its own, the marsupials diversified into many different kinds. 1

C. Placentals must have evolved last, from a primitive ancestor, similar to the marsupials, or from a common ancestor of the two groups. 1

This must have occurred on another land mass after Australia had moved away. 1

Placentals would thus have been able to spread to all other land masses, except Australia. 1

In most places, they eliminated the marsupials by competing more successfully for food and living space, or by preying on the marsupials. 1

Possible: 12

Maximum: 8

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 05
UNIT NAME: THEORY OF EVOLUTION

TOPIC: Paleontology
CURRICULAR EMPHASIS: Nature of Science

INSTRUMENT CODE: B051KaER.06
GUIDELINE OBJECTIVE CODE: 51Ka
INSTRUMENT TYPE: ER
KLOPFER: A.1, A.2, A.2, A.4, A.9, F.1
DIFFICULTY LEVEL: H
TIME ALLOCATION:

KEYWORDS: Continental drift isolation adaptive radiation.

Guideline Objective

Students will be expected to name and briefly describe the lines of evidence from areas of biology which support and are explained by the theory of evolution, i.e. evidence from paleontology, comparative anatomy (homologous and analogous structures), embryology, comparative biochemistry, selective breeding and the geographical distribution of species.

Item Focus

The student should be able to use the evidence from paleontology to support the theory of continental drift.

Item

Refer to Figure 5K.4.

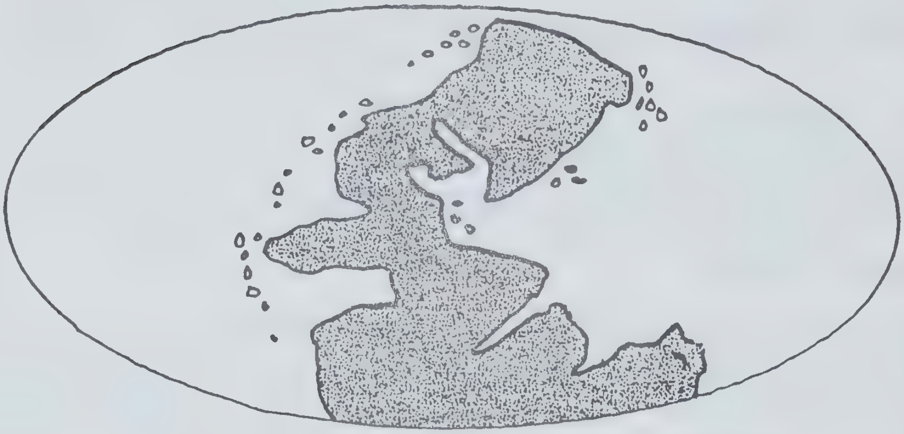
Figure 5K.4 provides a brief summary of past earth history.

The theory of Continental Drift gives some insight into evolutionary events. Most evidence for the theory of continental drift is derived from geological observations but a biological observation has also been cited. This is the observation that fossil mammals show a great deal more diversity than fossil reptiles.

Explain, using facts from Figure 5K.4 and your knowledge of biology, how this observation supports the theory of continental drift.

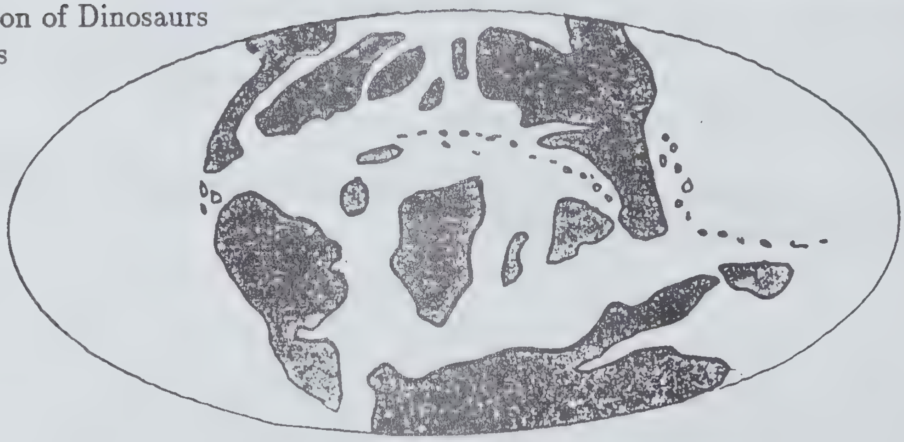
RECONSTRUCTIONS OF THE POSITIONS OF THE CONTINENTS AT TIMES IN THE EARTH'S PAST

Early Mesozoic
"Age of Reptiles"
First Dinosaurs



Mid Mesozoic

Late Mesozoic
Massive Extinction of Dinosaurs
Rise of Mammals



Response/Marking Scheme

According to Figure 5K.4, at the time that reptiles were evolving,	1
there was only one very large continent (Pangea) on earth.	1
When mammals were evolving,	1
there were numerous smaller continents.	1
The interior of Pangea, being far from oceans, would have	1
been a desert area, unsuitable for most forms of life,	1
and the peripheral parts of the continent, where suitable habitats were present,	1
would all be interconnected.	1
Therefore, some gene flow could take place between species occupying them.	1
Also, early reptiles were likely poikilothermic and would	1
be confined to the equatorial portions of the continent.	1
Thus, uniformity of habitat	1
and lack of reproductive isolation would limit diversity	1
among reptiles. When mammals were evolving, a greater diversity of habitats would be available -	1
homeothermic physiology evolved,	1
and reproductive isolation would develop between the early populations of mammals,	1
as continents became separated	1
and many mountain ranges were formed.	1
This would lead to a greater diversity among the mammals.	

Possible: 18

Maximum: 12

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 05
UNIT NAME: THEORY OF EVOLUTION

TOPIC: Comparative Embryology
CURRICULAR EMPHASIS: Nature of Science

INSTRUMENT CODE: B051KaER.07
GUIDELINE OBJECTIVE CODE: 51Ka
INSTRUMENT TYPE: ER
KLOPFER: A.1, A.2, A.3, A.4, A.5, A.6, A.9, E.1
DIFFICULTY LEVEL: H
TIME ALLOCATION:

KEYWORDS: embryology phylogeny

Guideline Objective

Students will be expected to name and briefly describe the lines of evidence from areas of biology which support and are explained by the theory of evolution, i.e. evidence from paleontology, comparative anatomy (homologous and analogous structures), embryology, comparative biochemistry, selective breeding and the geographical distribution of species.

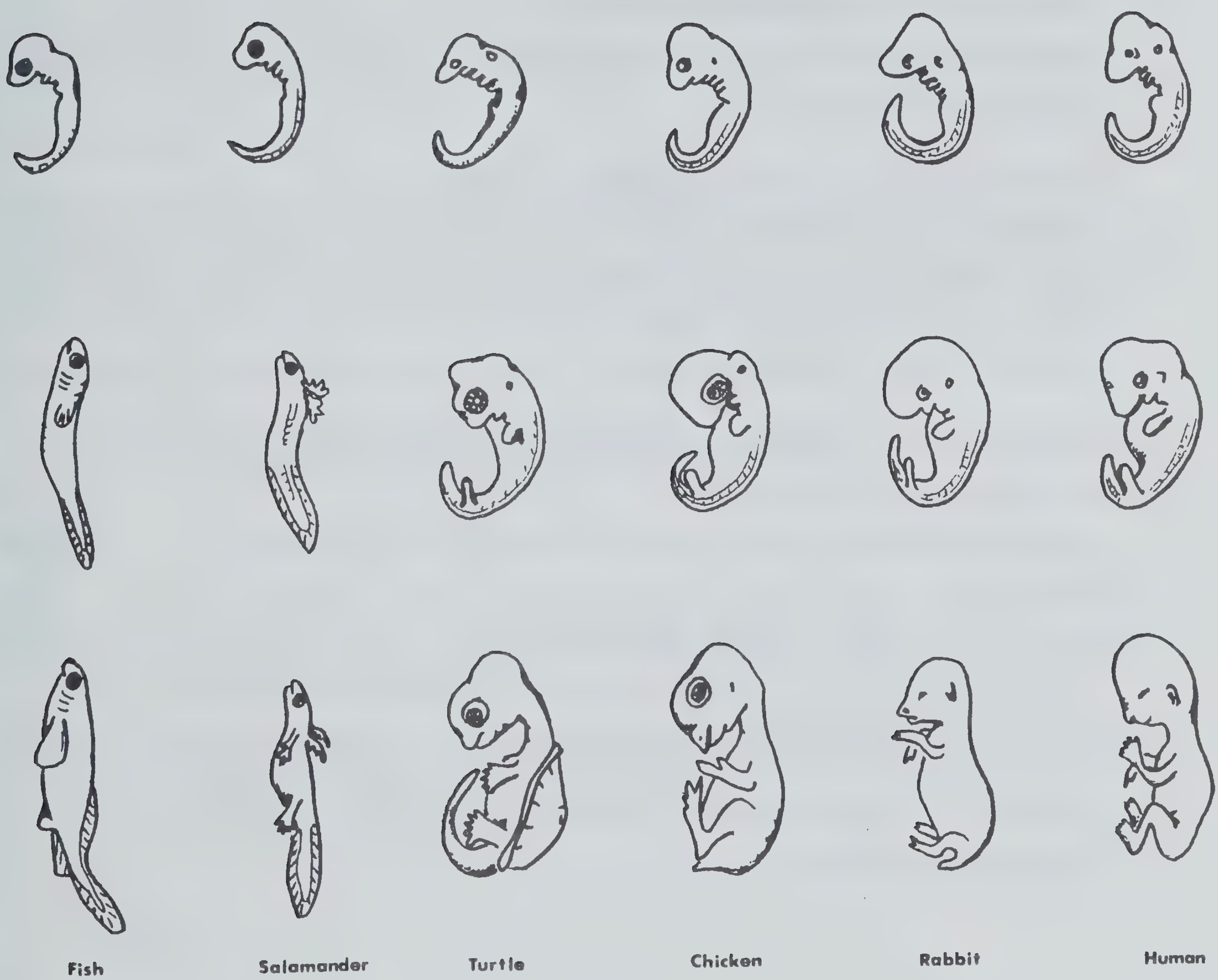
Item Focus

The student should be able to evaluate knowledge of the development of embryos in light of the theory of evolution.

Item

Refer to Figure 5K.5.

COMPARATIVE DEVELOPMENT OF LATE STAGES OF SEVERAL VERTEBRATE EMBRYOS



The figure illustrates three comparative stages in the development of six different vertebrates. In the past, this evidence led some biologists to suggest that "ontogeny recapitulates phylogeny".

A. What evidence from Figure 5K.5 supports the quoted phrase? Comment on the validity of the phrase.

B. Discuss the significance of the comparative development of embryos as evidence to support the theory of evolution.

Response/Marking Scheme

A. There are similarities in the structures of all the embryos at the earliest stage. 1

As development progresses, the similarities become less evident; differences more evident. 1

The phrase is not considered valid today, because 1

organisms do not repeat their evolutionary history 1

during their development.

B. The development of a vertebrate begins with a zygote 1

and goes on to form an embryonic disc 1

from which the three germ layers arise. 1

From these, all the tissues and organs develop. 1

From such similar beginnings, one can infer a common evolutionary origin. 1

After the neural tube forms, significant differences arise, such as the size of the cephalic region of the tube. 1

Pharyngeal pouches appear, and become gills in the fish and salamander, but develop into 1

ear and throat structures in terrestrial vertebrates. 1

Such parallel developments must be organized by similar genetic controls, inherited from common ancestors. 1

The more closely related two organisms are in their embryological development, the smaller the amount of evolutionary divergence has occurred from a common ancestor. 1

Possible: 14

Maximum: 10

Quality: 2

Total: 12

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 05
UNIT NAME: THEORY OF EVOLUTION

TOPIC: The Modern Theory
CURRICULAR EMPHASIS: Nature of Science

INSTRUMENT CODE: B051KaER.08
GUIDELINE OBJECTIVE CODE: 51Ka
INSTRUMENT TYPE: ER
KLOPFER: A.1, A.2, A.3, A.5.
DIFFICULTY LEVEL: H
TIME ALLOCATION:

KEYWORDS: life cycle

Guideline Objective

Students will be expected to name and briefly describe the lines of evidence from areas of biology which support and are explained by the theory of evolution, i.e. evidence from paleontology, comparative anatomy (homologous and analogous structures), embryology, comparative biochemistry, selective breeding and the geographical distribution of species.

Item Focus

The student should be able to use the modern theory of evolution to hypothesize about the advantage of one kind of life cycle over another.

Item

Most insects have a short life cycle, reaching maturity within a few days or weeks, and producing offspring soon. Most mammals have a long life cycle, taking months or years to reach maturity before they can reproduce.

Hypothesize about the advantages and disadvantages of one kind of life cycle over the other in terms of the process of evolution.

Response/Marking Scheme

(There are many other differences between insects and mammals that are likely to affect evolutionary advantage as much as life cycle: number of offspring, energy budget, reasoning ability vs. instinct, size, etc.)

On the basis of life cycle, a short cycle might give an	1
advantage in that following an ecological disaster that might destroy a high percentage of the population,	1
a few survivors could soon repopulate a community.	2
In terms of evolution, a population with a short cycle would produce many more generations	1
for natural selection to act upon in selecting the	1
best adapted mutations,	1
gradually shaping the population to better suit the environent.	1
When food is limited, an organism with a short cycle might have an advantage of getting quickly to reproductive maturity,	2
thus ensuring that offspring are left for the future.	2
Possible:	12
Maximum:	8
Quality:	2
Total:	10

Teacher Notes

DRAFT

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B051KaER.09
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 51Ka
UNIT NUMBER: 05	INSTRUMENT TYPE: ER
UNIT NAME: THEORY OF EVOLUTION	KLOPFER: A.1, A.2, A.3, A.4, A.5, D.1, D.3, D.6
TOPIC: Comparative Biochemistry	DIFFICULTY LEVEL:
CURRICULAR EMPHASIS: Nature of Science	TIME ALLOCATION:

KEYWORDS: biochemistry embryology homology

Guideline Objective

Students will be expected to name and briefly describe the lines of evidence from areas of biology which support and are explained by the theory of evolution, i.e. evidence from paleontology, comparative anatomy (homologous and analogous structures), embryology, comparative biochemistry, selective breeding and the geographical distribution of species.

Item Focus

The student should be able to interpret biochemical homologies among organisms as evidence of evolutionary relationships.

Item

There are some homologies among the biochemical pathways of the excretion of nitrogenous wastes in different groups of organisms. The breakdown of amino acids results in ammonia, a highly toxic waste. Aquatic animals excrete ammonia in excess water. Animals adapted for life out of water convert ammonia into either soluble urea, or insoluble uric acid. Both urea and uric acid are much less toxic. Many fish excrete nitrogenous waste as ammonia. Frog tadpoles excrete ammonia, but the adult frog excretes urea. Very early stage embryos of birds excrete ammonia, but later urea, and finally, about the time of hatching, they excrete uric acid. What does this evidence suggest in evolutionary terms?

Response/Marking Scheme

The genes controlling the production of these distinct 2

metabolic end-products must exist within the bird. At a certain stage of development, a gene system must be activated. 1

or another repressed, by some environmental influence 2

that affects development. This suggests that during its embryological development, a bird goes through a fish-like stage and an amphibian stage, at least in its biochemistry. 2

This also suggests an evolutionary relationship linking fish, amphibians, and birds. Or, that birds are descended from ancestors that were fish and amphibians at very early times. 2

Possible: 9

Maximum: 6

Teacher Notes

DRAFT

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B051KaER.10
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 51Ka
UNIT NUMBER: 05	INSTRUMENT TYPE: ER
UNIT NAME: THEORY OF EVOLUTION	KLOPFER: A.1, A.2, A.3, A.4, A.5, A.6, A.9
TOPIC: Comparative Anatomy	DIFFICULTY LEVEL: M
CURRICULAR EMPHASIS: Nature of Science	TIME ALLOCATION:

KEYWORDS: homology

Guideline Objective

Students will be expected to name and briefly describe the lines of evidence from areas of biology which support and are explained by the theory of evolution, i.e. evidence from paleontology, comparative anatomy (homologous and analogous structures), embryology, comparative biochemistry, selective breeding and the geographical distribution of species.

Item Focus

The student should be able to identify similar skeletal structures among mammals, and associate these with evolutionary relationships.

Item

Refer to Figure 5K.6.

FORELIMB BONES OF THREE MAMMALS

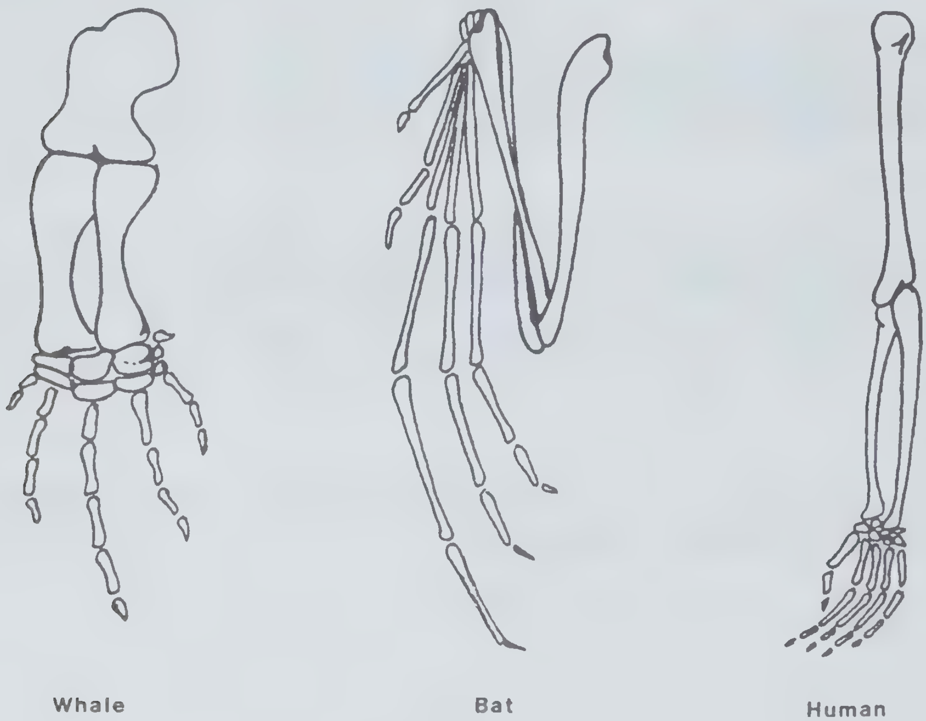


Figure 5K.6 represents the bones of the forelimbs of three mammals.

A. Name and define the term for this kind of evidence.

B. Interpret the evidence in terms of the theory of evolution.

Response/Marking Scheme

A. This is an example of homology or comparative anatomy.	1
Homology is the occurrence of similar body structures in organisms that appear to be quite different.	2
B. The forelimbs of these organisms are adapted for such widely diverse functions as flying, swimming, and grasping.	2
Yet these limbs show simple modifications of the same basic plan.	2
The common structures are readily identified: humerus, radius, ulna, carpals and phalanges.	2
The lengths and thicknesses of the bones vary	1
greatly to accommodate their special functions.	1
Yet the bones continue to be present, and in the same relationships to one another.	1
This evidence suggests that evolutionary change is the result of the modification of a basic body plan.	1
This is most probably because of descent from a common ancestor.	1
Possible:	14
Maximum:	8

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B051KaER.11
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 51Ka
UNIT NUMBER: 05	INSTRUMENT TYPE: ER
UNIT NAME: THEORY OF EVOLUTION	KLOPFER: A.1, A.2, A.3, A.4, A.5, A.6, A.9
TOPIC: Cell Structure/Function	DIFFICULTY LEVEL: M
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:

KEYWORDS: cell structure cell functioning

Guideline Objective

Students will be expected to name and briefly describe the lines of evidence from areas of biology which support and are explained by the theory of evolution, i.e. evidence from paleontology, comparative anatomy (homologous and analogous structures), embryology, comparative biochemistry, selective breeding and the geographical distribution of species.

Item Focus

The student should be able to illustrate evidence of the evolutionary relationship of all organisms at the cellular level.

Item

Most scientists think that all organisms may be descended from a common ancestor. Give five statements derived from detailed studies of cell structure and functioning to support this hypothesis.

Response/Marking Scheme

Any five, such as the following:

All organisms are constructed of cells.
The structure of cell membranes is chemically similar.
All have nucleic acids, the genetic material,
composed of the same nucleotide bases.
All eukaryotic cells reproduce by mitosis.
All have essentially similar enzymes for
metabolic pathways,such as the electron transport chain.
All cells have ribosomes.

Maximum: 5

Teacher Notes

DRAFT

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 05
UNIT NAME: THEORY OF EVOLUTION

TOPIC: Comparative Anatomy
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B051KaER.12
GUIDELINE OBJECTIVE CODE: 51Ka
INSTRUMENT TYPE: ER
KLOPFER: A.1, A.2, A.3, A.11
DIFFICULTY LEVEL: M
TIME ALLOCATION:

KEYWORDS: vertebrate brains

Guideline Objective

Students will be expected to name and briefly describe the lines of evidence from areas of biology which support and are explained by the theory of evolution, i.e. evidence from paleontology, comparative anatomy (homologous and analogous structures), embryology, comparative biochemistry, selective breeding and the geographical distribution of species.

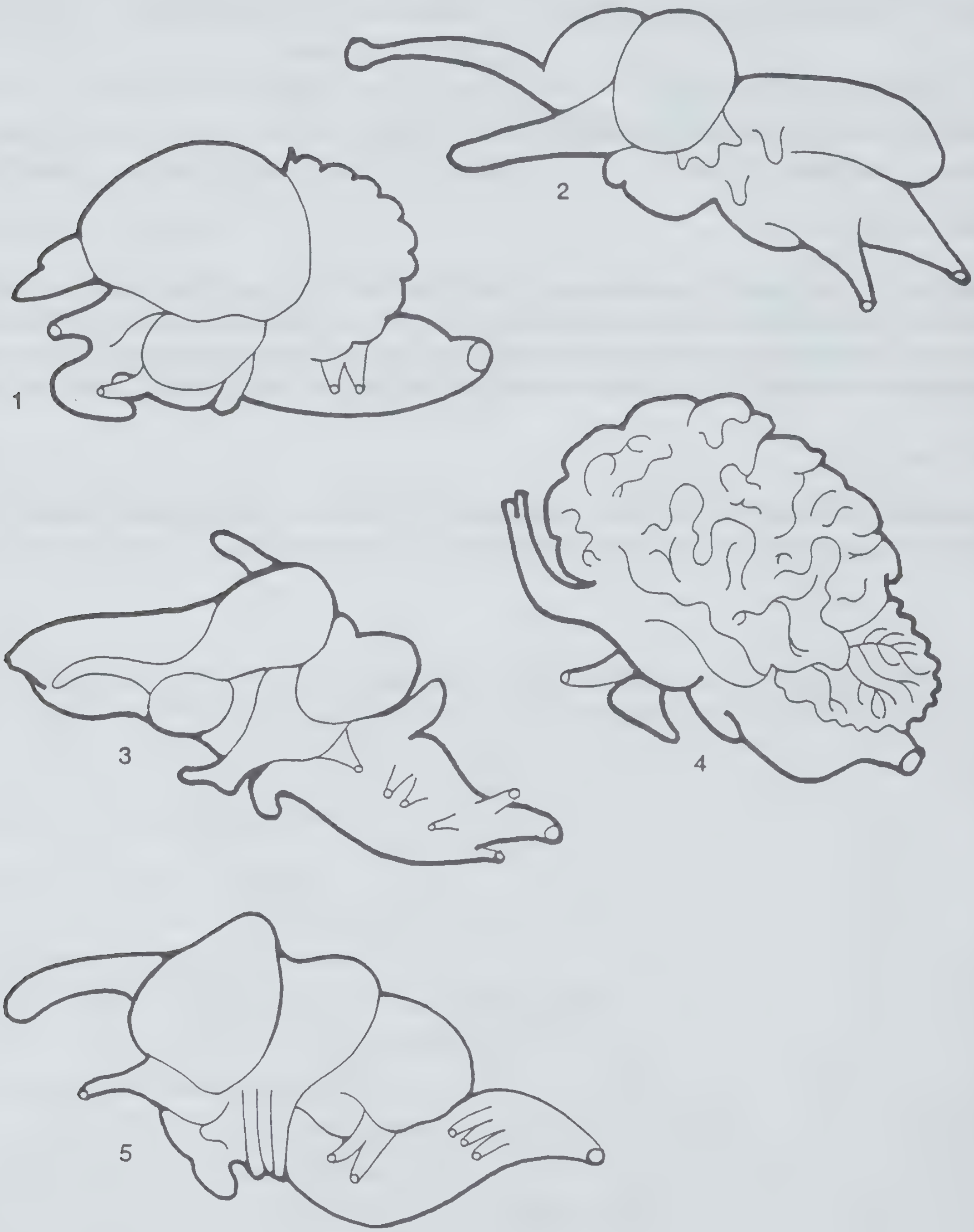
Item Focus

The student should be able to identify diagrams of five different classes of vertebrate brains, and identify an arrangement of them in sequence by classes.

Item

Refer to Figure 5K.7.

BRAINS OF SEVERAL CLASSES OF VERTEBRATES



The diagrams of brains represent different classes of vertebrates. The diagrams are not drawn to scale.

A. Arrange them in an evolutionary sequence.

B. Explain the reasons you placed each in its relative position.

Response/Marking Scheme

A. 2, 3, 5, 1, 4.

B. 2 represents a fish brain, considered earliest in 1
evolutionary sequence in that the olfactory and optic lobes are large for receiving stimuli, while the 2
cerebellum is large to allow for co-ordination of reflex actions. 2
3 represents the brain of an amphibian, derived from 1
a fish-like ancestor, and slightly more advanced in having enlarged cerebral hemispheres between the olfactory and optic lobes. 2
5 is a reptilian brain, more advanced than the 1
amphibian brain in having further enlargement of the cerebral hemispheres, although the olfactory and 2
optic lobes, and the cerebellum are still pronounced. 2
1 is the brain of a bird with considerable 1
enlargement of the cerebrum, but still a much enlarged cerebellum, 2
a centre for instinctive responses. 2
4 is a mammalian brain, in which the cerebrum 1
is the main part, and greatly convoluted to 2
increase the surface area of grey matter. The olfactory and optic lobes are reduced, as is the cerebellum. 2

Possible: 25

Maximum: 20

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B051KaER.13
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 51Ka
UNIT NUMBER: 05	INSTRUMENT TYPE: ER
UNIT NAME: THEORY OF EVOLUTION	KLOPFER: A.1, A.3, A.5, C.1, C.2, D.1, D.3, D.6
TOPIC: Comparative Biochemistry	DIFFICULTY LEVEL: H
CURRICULAR EMPHASIS: Nature of Science	TIME ALLOCATION:

KEYWORDS: biochemistry embryology graphical analysis

Guideline Objective

Students will be expected to name and briefly describe the lines of evidence from areas of biology which support and are explained by the theory of evolution, i.e. evidence from paleontology, comparative anatomy (homologous and analogous structures), embryology, comparative biochemistry, selective breeding and the geographical distribution of species.

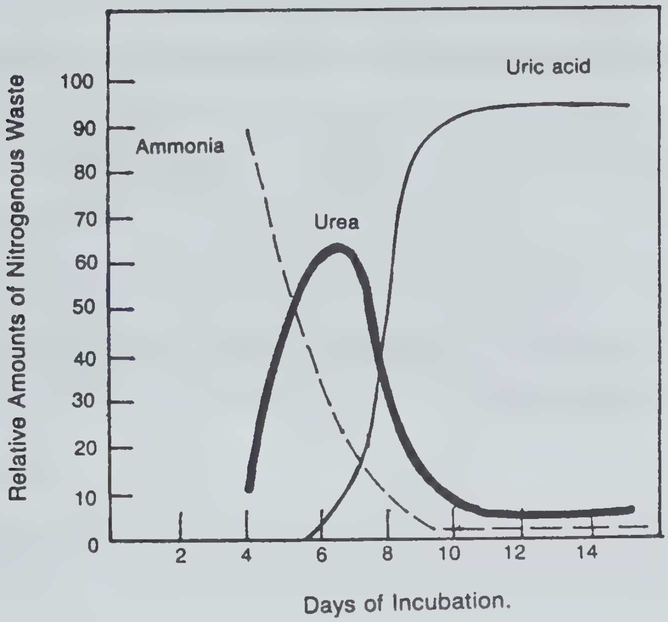
Item Focus

The student should be able to interpret biochemical homologies among organisms as evidence of evolutionary relationships.

Item

Refer to Figure 5K.8.

EXCRETORY PRODUCTS OF A DEVELOPING BIRD EMBRYO



The breakdown of amino acids results in ammonia, a highly toxic waste. Aquatic animals excrete ammonia in excess water. Animals adapted for life out of water convert ammonia into either soluble urea, or insoluble uric acid. Both urea and uric acid are less toxic. The nitrogenous waste of many fish is excreted as ammonia. Tadpoles also excrete ammonia, but adult frogs excrete urea. The graph in Figure 5K.8 shows the metabolic wastes excreted during different stages of the embryological development of a bird.

Interpret the data shown in genetic and evolutionary terms.

Response/Marking Scheme

The graph shows that birds, during development, go through stages in which they produce different excretory products, 2

ammonia in earliest stage, changing to urea and later uric acid. 2

The genes governing the three distinct metabolic end-products must all exist within birds, 1

and at certain stages of development, a gene system is activated or modified at the expense of others by some environmental developmental influence. 2

This suggests that there is an evolutionary relationship linking fish, amphibians, and birds, 1

and that birds, in their development, go through a fish- like stage and an amphibian stage, at least biochemically. 1

Possible: 9

Maximum: 7

Quality: 2

Total: 9

Teacher Notes

DRAFT

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B051KaER.14
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 51Ka
UNIT NUMBER: 05	INSTRUMENT TYPE: ER
UNIT NAME: THEORY OF EVOLUTION	KLOPFER: A.1, A.2, A.3, A.4, A.5, A.9, D.1, D.3
TOPIC: Comparative Biochemistry	DIFFICULTY LEVEL: H
CURRICULAR EMPHASIS: Nature of Science	TIME ALLOCATION:

KEYWORDS: biochemistry

Guideline Objective

Students will be expected to name and briefly describe the lines of evidence from areas of biology which support and are explained by the theory of evolution, i.e. evidence from paleontology, comparative anatomy (homologous and analogous structures), embryology, comparative biochemistry, selective breeding and the geographical distribution of species.

Item Focus

The student should be able to describe and explain the relationship between similarities in protein structure, and time of divergence from a common ancestor.

Item

Cytochrome *c* is a molecule found in nearly all living things: monerans, protists, fungi, plants and animals. It plays an important role in the electron transport chain, helping to control energy release in every cell. Cytochrome *c* is a short protein, consisting of about 110 amino acids.

When the sequence of amino acids in the cytochrome *c* molecules of different organisms is determined, minor differences are found. For example, although humans and chimpanzees have identical cytochrome *c* molecules, while that of the rhesus monkey differs at only one amino acid site. Pigs, cows and sheep have identical cytochrome *c* molecules, which differ from that of humans at 10 sites. Even wheat cytochrome *c* is similar to that of humans at 75 sites, differing at only 35 sites, although it does have an extra 7 sites added at one end.

A. What does such similarity suggest about the evolution of the cytochrome *c* molecule?

B. What does such evidence suggest about the organisms mentioned above?

Response/Marking Scheme

A. Cytochrome *c* is so important to life that only organisms in which it remained stable over long periods of time stayed alive. 2

If mutations changed it very much, it would not have continued to transfer energy effectively, and the organism possessing the mutation would have been selected against. 2

B. The more recently that two organisms have shared a common ancestor, the more alike they will be in protein structure. 1

Organisms with more remote common ancestors have had time to accumulate more mutations, and their proteins will differ at more amino acid sites. 2

Thus humans and chimpanzees must have diverged only very "recently" from a common ancestor (in terms of geological time, say between 5 and 10 million years ago). 1

Similarly, the common ancestor of pigs, cows and sheep must have lived relatively recently. 1

The common ancestor of the primates and ungulates must have lived a very long time ago. 1

Wheat, a plant, must have been separate from the animals for a vast period: the common ancestor of plants and animals probably existed very early in the history of life. 1

Possible: 11

Maximum: 8

Quality: 2

Total: 10

Teacher Notes

DRAFT

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B051KaER.15
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 51Ka
UNIT NUMBER: 05	INSTRUMENT TYPE: ER
UNIT NAME: THEORY OF EVOLUTION	KLOPFER: A.1, A.2, A.3, A.4, A.5, A.6, A.9, D.1, D.3, D.6
TOPIC: Comparative Biochemistry	DIFFICULTY LEVEL: M
CURRICULAR EMPHASIS: Nature of Science	TIME ALLOCATION:

KEYWORDS: biochemistry amino acid haemoglobin

Guideline Objective

Students will be expected to name and briefly describe the lines of evidence from areas of biology which support and are explained by the theory of evolution, i.e. evidence from paleontology, comparative anatomy (homologous and analogous structures), embryology, comparative biochemistry, selective breeding and the geographical distribution of species.

Item Focus

The student should be able to explain that changes in the amino acid sequence of haemoglobin are the result of changes in the DNA code, and that the more closely two organisms are related, the more similar will be the sequence of amino acids in their haemoglobin.

Item

Refer to Table 5.1.

Table 5.1

NUMBER OF AMINO ACID DIFFERENCES FROM THE HUMAN BETA CHAIN IN THE HAEMOGLOBINS OF VARIOUS SPECIES	
Human beta chain	0
Gorilla	1
Gibbon	2
Rhesus monkey	8
Dog	15
Horse, cow	25
Mouse	27
Gray kangaroo	38
Chicken	45
Frog	67
Lamprey	125
Sea slug (a mollusk)	127
Soybean (leghaemoglobin)	124

Table 5.1 compares the amino acid sequences of the beta chains of the haemoglobin molecules of a number of different organisms with that of the human.

Explain how this evidence could support evolutionary theory.

Response/Marking Scheme

Haemoglobin is a protein, made of amino acids assembled in a particular sequence.	1
The sequence results from the reading of the DNA code.	1
Any change in the sequence of amino acids of a particular protein is the result of changes in the DNA.	1
The more distant in evolutionary time that two organisms had a common ancestor, the more time would have been available for mutations to accumulate, and hence for changes in the amino acid sequences.	2
Conversely, the more similar the structure of a protein in two different species, the more recently the two organisms may have shared a common ancestor.	1
Thus, humans and gorillas must have diverged most recently from a common ancestor;	1
and the common ancestor of plants and vertebrates may have lived very early in the history of life.	1
Possible:	8
Maximum:	5

Teacher Notes

DRAFT

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 05
UNIT NAME: THEORY OF EVOLUTION

TOPIC: Comparative Biochemistry
CURRICULAR EMPHASIS: Nature of Science

INSTRUMENT CODE: B051KaER.16
GUIDELINE OBJECTIVE CODE: 51Ka
INSTRUMENT TYPE: ER
KLOPFER: A.1, A.2, A.3, A.5, A.10
DIFFICULTY LEVEL: M
TIME ALLOCATION:

KEYWORDS:

Guideline Objective

Students will be expected to name and briefly describe the lines of evidence from areas of biology which support and are explained by the theory of evolution, i.e. evidence from paleontology, comparative anatomy (homologous and analogous structures), embryology, comparative biochemistry, selective breeding and the geographical distribution of species.

Item Focus

The student should be able to explain similarities between structure and functions of different hormones in terms of evolution.

Item

Scientists discovered in 1984 that the hormone secreted by the hypothalamus to stimulate the pituitary gland to secrete growth hormone (GHRF) is very potent at causing the pancreas to secrete digestive juices, a function normally performed by the hormone, secretin. GHRF and secretin were found to have similar chemical structures. Use evolutionary arguments to suggest why this should be the case.

Response/Marking Scheme

Since the two hormones have similar effects on the pancreas they probably have similar primary sequences of amino acids.	1
Probably at some time in the past, a single gene was duplicated at least once.	1
The two genes underwent mutations, becoming slightly	1
different, and the resulting genes have been maintained by natural selection, for different tasks.	1
Since the two genes have been evolving separately for a relatively short time, each hormone still has	1
structural and functional characteristics that it shares with the other.	

Possible: 5

Maximum: 5

Teacher Notes

DRAFT

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 05
UNIT NAME: THEORY OF EVOLUTION

TOPIC: Evolution of Homeostasis
CURRICULAR EMPHASIS: Nature of Science

INSTRUMENT CODE: B051KaER.17
GUIDELINE OBJECTIVE CODE: 51Ka 61Aa 61Ab

INSTRUMENT TYPE: ER
KLOPFER: A.1, A.2, A.3, A.5, A.5, A.9, C.2

DIFFICULTY LEVEL: M
TIME ALLOCATION:

KEYWORDS: extracellular fluid

Guideline Objective

Students will be expected to name and briefly describe the evidence from areas of biology which support and are explained by the theory of evolution, i.e. evidence from comparative biochemistry, and to develop a curiosity about the mechanisms involved in homeostatic control and stability of the internal environment.

Item Focus

The student should be able to identify the ions common to the ECF of multicellular organisms and the sea, and suggest the hypothesis to account for the similarity.

Item

About 1930, A. B. MacCallum of the University of Toronto observed that each multicellular organism carries in its extracellular fluid approximately the same concentration of ions as there is in sea water — “a sea within”.

A. What are the five ions of highest concentration in sea water and in the body fluids?

B. Suggest a reason that multicellular organisms might maintain fluids similar in composition.

C. Discuss a possible hypothesis to account for MacCallum’s observations.

Response/Marking Scheme

A. sodium, chloride, potassium, calcium, magnesium 5
(Note: phosphate and bicarbonate might be accepted).

B. Each organism has similar life processes, and similar biochemical mechanisms; therefore they require the same ions to make the reactions possible. 2

C. Life may have originated in the sea, and the initial chemical reactions that depended on the ions in sea water may have become selected for in the genetic systems of all multicellular organisms. 3
This could be explained by the hypothesis that most multicellular organisms are descended from a common ancestor. 2

Possible: 12

Maximum: 10

Teacher Notes

DRAFT

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B051KaER.18
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 51Ka
UNIT NUMBER: 05	INSTRUMENT TYPE: ER
UNIT NAME: THEORY OF EVOLUTION	KLOPFER: A.1, A.2, A.3, A.4, A.5, A.6, A.9
TOPIC: Comparative Anatomy	DIFFICULTY LEVEL: M
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:

KEYWORDS: homology karyotype

Guideline Objective

Students will be expected to name and briefly describe the lines of evidence from areas of biology which support and are explained by the theory of evolution, i.e. evidence from paleontology, comparative anatomy (homologous and analogous structures), embryology, comparative biochemistry, selective breeding and the geographical distribution of species.

Item Focus

The student should be able to explain that similarities in karyotype reflect evolutionary relationships.

Item

If two species appear very similar in structure and appearance, such as the gorilla and chimpanzee, what would you expect to observe if you were to examine the karyotypes of their chromosomes? Explain your answer.

Response/Marking Scheme

They would appear very similar.	1
The two species may have had a common	1
ancestor, fairly recently in evolutionary history.	1
Not enough time has elapsed for major changes in the chromosome structure to have occurred.	1
Possible:	4
Maximum:	4

Teacher Notes

DRAFT

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B051KaER.19
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 51Ka
UNIT NUMBER: 05	INSTRUMENT TYPE: ER
UNIT NAME: THEORY OF EVOLUTION	KLOPFER: A.1, A.2, A.3, A.4, A.5, A.6, A.9, D.6
TOPIC: Comparative Biochemistry	DIFFICULTY LEVEL: M
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:

KEYWORDS: biochemistry DNA homology

Guideline Objective

Students will be expected to name and briefly describe the lines of evidence from areas of biology which support and are explained by the theory of evolution, i.e. evidence from paleontology, comparative anatomy (homologous and analogous structures), embryology, comparative biochemistry, selective breeding and the geographical distribution of species.

Item Focus

The student should be able to predict the relationship between genome differences and evolutionary history.

Item

All organisms show some homologous characteristics. Often this is obvious morphologically, but sometimes homologies show only in biochemical pathways.

A technique called "DNA hybridization" has been used to compare the DNA sequences of primates. The technique consists of making single copy preparations of the DNA of two species. Repetitive sequences of DNA are eliminated from the copies, which are then put together to form complexes ("hybridize"). The more similar the DNA sequences are, the stronger will be the bonding between the two sets. As the temperature is raised, there will be a tendency for the two sets to separate again. The more similar the DNA sequences, the higher will be the temperature needed for dissociation of the two sets.

A. If you could use this technique to compare the DNA sequences of all living creatures, what would you expect to find?

B. Why is this DNA hybridization technique more precise in determining relationships between species than morphological methods or amino acid sequencing?

Response/Marking Scheme

A. Since all of the homologies between organisms are the result of the genetics of the organisms, one expects to find some genes the same in different organisms. 1

The more similar the genomes, the more closely related the organisms would be. 1

Similarities in the DNA sequences should help in constructing the phylogenetic history of life. 1

"Every organism's evolutionary history is encrypted in its genes."

B. Because several different anticodons specify the same amino acid, 1

changes in the nucleotide sequences of a genome are 1

not always reflected as a change in the amino acid sequence of a protein. 1

Changes in nucleotide sequence are even more rarely reflected in the functioning part of a protein, and 1

hence in morphological, physiological, or behavioural changes. 1

Consequently, the comparison of the DNA sequences between organisms is much more precise in determining evolutionary relationships than amino acid sequences or similarities in morphology, physiology, or behaviour. 1

The more remote two species are in relationship, the more diverse will be their DNA, their amino acid sequences, their physiology, morphology and behaviour. 1

Possible: 10

Maximum: 5

Quality: 2

Total: 10

Reference: Lewin, Roger. "DNA reveals surprises in Human Family Tree" *Science*, Vol. 226: 1179 -82, December 7, 1984

Teacher Notes

DRAFT

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 05
UNIT NAME: THEORY OF EVOLUTION

TOPIC: Modern Theory
CURRICULAR EMPHASIS: Nature of Science

INSTRUMENT CODE: B051KaER.20
GUIDELINE OBJECTIVE CODE: 51Ka
INSTRUMENT TYPE: ER
KLOPFER: A.1, A.2, A.3, A.9, F.1
DIFFICULTY LEVEL: H
TIME ALLOCATION:

KEYWORDS: DNA protein synthesis

Guideline Objective

Students will be expected to name and briefly describe the lines of evidence from areas of biology which support and are explained by the theory of evolution, i.e. evidence from paleontology, comparative anatomy (homologous and analogous structures), embryology, comparative biochemistry, selective breeding and the geographical distribution of species.

Item Focus

The student should be able to relate new information to the modern theory of evolution.

Item

In some organisms, DNA consists of many relatively short segments (120 to 150 bases in length) called <u>exons</u>, which carry the actual hereditary information. Between the exons are segments, usually much longer (50 to 20 000 bases in length), called <u>introns</u>. Introns do not carry actual hereditary information. They are replicated along with the exons, but during either transcription or translation, they are cut out so that only a series of spliced-together exons contributes to the coding for the sequence of amino acids in the cell's polypeptides.

Investigations have revealed that the same exon may contribute to the structure of very different polypeptides. For example, the cell membrane receptor for certain lipoproteins is encoded by 18 exons. Only 5 of these are unique to the receptor; the remaining 13 are also found helping to encode information for the assembly of such diverse polypeptides as epidermal growth factor, blood clotting factors, and one of the blood components directing the immune response to foreign antigens.

Explain clearly how the development of exons and introns and the splicing of exons would contribute to evolution, particularly to the rate of evolution of those organisms that possess them.

Response/Marking Scheme

Evolution may arise from the gradual accumulation of mutations	1
that happen to cause amino acid substitutions that improve the functioning of a particular protein	1
or make the protein able to perform some new function.	1
So that the new function does not eliminate a previous function,	1
it is important that some genes be duplicated.	1
If exons can be duplicated,	1
and then joined randomly to other exons	1
in much the same way that alleles are randomly assorted and recombined during meiosis,	1
then newly synthesized proteins could receive functional portions already highly perfected	1
as part of a previously existing protein.	1
For example, in the example cited, the capacity to become integrated with the cell membrane may have been received by the lipoprotein receptor, already perfected, from the immune proteins, (or vice versa).	1
Thus a protein evolving to perform a new function would not have to evolve again a portion to perform a sub-function that had already evolved elsewhere in the cell or body many generations before.	1
The short length of the exon would make it unlikely to be disrupted during crossing over while nuclear division is occurring.	1
The great length of the introns would maximize the opportunity for new random combinations of exons to occur during nuclear divisions.	1
Possible:	14
Maximum:	10
Quality:	2
Total:	12

Teacher Notes

DRAFT

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 05
UNIT NAME: THEORY OF EVOLUTION

TOPIC: Comparative Biochemistry
CURRICULAR EMPHASIS: Nature of Science

INSTRUMENT CODE: B051KaER.21
GUIDELINE OBJECTIVE CODE: 51Ka
INSTRUMENT TYPE: ER
KLOPFER: A.1, A.2, A.3, A.5
DIFFICULTY LEVEL: H
TIME ALLOCATION:

KEYWORDS: proteins mutation

Guideline Objective

Students will be expected to name and briefly describe the lines of evidence from areas of biology which support and are explained by the theory of evolution, i.e. evidence from paleontology, comparative anatomy (homologous and analogous structures), embryology, comparative biochemistry, selective breeding and the geographical distribution of species.

Item Focus

The student should be able to explain how the history of genetic change has come to be recorded in protein molecules.

Item

The following statement, written by E. Zuckerkandl in an article "The Evolution of Hemoglobin," appeared in *Scientific American*, May, 1965:

> "Every living thing carries within itself a richly detailed record of its antecedents from the beginning of life on earth. This record is preserved in coded form in the giant molecules of deoxyribonucleic acid (DNA)...The genetic record is also expressed more tangibly in the protein molecules that endow the organism with its form and function."

Explain how the processes involved in evolution could have produced a record of genetic change expressed in protein molecules.

Response/Marking Scheme

Evolutionary processes include random genetic change,	1
followed by natural selection of well-adapted phenotypes.	1
Gene replication often results in many copies of genes within the genome.	1
Mutations produce changed codons, which sometimes call for different amino acids to be assembled into a protein.	1
(Changes at the 3rd position of a codon often do not result in a changed amino acid, because the code is redundant.)	1
When the structure of a particular protein from a range of species is compared, minor changes in the sequence and number of amino acids are found.	2
Species that appear to be more closely related, such as humans, chimpanzees and gorillas, show fewer differences in their protein structure.	2
Species that do not appear to be related, such as humans, fishes, plants and bacteria, show more differences in the sequence and numbers of amino acids.	2
It seems probable that species which had a common ancestor very long ago would have accumulated more mutations and show more differences in protein structure than species that had diverged only recently from a common ancestor.	2
Possible:	13
Maximum:	10
Quality:	2
Total:	12

Teacher Notes

DRAFT

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 05
UNIT NAME: THEORY OF EVOLUTION

TOPIC: Domestication
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B051KaER.22
GUIDELINE OBJECTIVE CODE: 51Ka
INSTRUMENT TYPE: ER
KLOPFER: A.1, A.2, A.3, A.5.
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: selective breeding

Guideline Objective

Students will be expected to name and briefly describe the lines of evidence from areas of biology which support and are explained by the theory of evolution, i.e. evidence from paleontology, comparative anatomy (homologous and analogous structures), embryology, comparative biochemistry, selective breeding and the geographical distribution of species.

Item Focus

The student should be able to explain how selective breeding has altered domestic species.

Item

Dogs have been domesticated for a very long time. Many new varieties of dogs have been developed for different purposes: to guard sheep, to pull sleds, to enter burrows of hunted animals, and to retrieve shot birds.

A. How is a new breed developed?

B. Once a new breed has been defined, how do breeders maintain it?

C. Why is a variety, such as the chihuahua, not called a new species?

Response/Marking Scheme

A.	(1) Breeders identify desirable traits,	1
	(2) select parents possessing these traits,	1
	(3) continue the selection generation after generation	1
	(4) while preventing adults with undesirable traits from mating.	1
B.	Steps 2, 3, and 4 from A are repeated.	3
C.	It is still capable of interbreeding with other varieties to produce viable, fertile offspring.	3
	Possible:	10
	Maximum:	7

Teacher Notes

DRAFT

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 05
UNIT NAME: THEORY OF EVOLUTION

TOPIC: Speciation

INSTRUMENT CODE: B051KaER.23
GUIDELINE OBJECTIVE CODE: 51Ka
INSTRUMENT TYPE: ER
KLOPFER: A.1, A.2, A.3, A.8, A.9, F.1
DIFFICULTY LEVEL: M
TIME ALLOCATION:

CURRICULAR EMPHASIS: Nature of Science

KEYWORDS: isolation

Guideline Objective

Students will be expected to name and briefly describe the lines of evidence from areas of biology which support and are explained by the theory of evolution, i.e. evidence from paleontology, comparative anatomy (homologous and analogous structures), embryology, comparative biochemistry, selective breeding and the geographical distribution of species.

Item Focus

The student should be able to explain differences in flora and fauna in a particular region of the basis of geographical barriers and corridors.

Item

Biologists have made some generalizations about the plants and animals of the extreme southern tip of Florida. Almost all the plants and marine fish of southern Florida are similar to species found in the West Indies, whereas most of the birds and land animals are similar to species found in the more northern areas of the United States.

Use evolutionary concepts to account for these observations.

Response/Marking Scheme

The oceans between Florida and the West Indies act as	1
both a barrier to species migration, and a	1
corridor for migration to species able to withstand the challenges of the salt water environment.	1
Marine fish can reach Florida from the West Indies, and	1
plants could be carried as seeds in the water, or by marine and migratory birds,	1
but other kinds of animals are dehydrated by salt water	1
so niches for such animals in Florida would be filled by migrants from further north, using the land corridor.	1
Plants and marine fish might also reach Florida from the north, but tropical migrants from the West Indies were probably better adapted to the Florida climate and sea	1
conditions than migrants from the north, and likely eliminated the latter in competition, by natural selection.	1
Possible:	9
Maximum:	6

Teacher Notes

DRAFT

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B051KaER.24
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 51Ka
UNIT NUMBER: 05	INSTRUMENT TYPE: ER
UNIT NAME: THEORY OF EVOLUTION	KLOPFER: A.1, A.2, A.3, A.8, A.9
	DIFFICULTY LEVEL: M
TOPIC: Convergent Evolution	TIME ALLOCATION:
CURRICULAR EMPHASIS: Nature of Science	

KEYWORDS: isolation

Guideline Objective

Students will be expected to name and briefly describe the lines of evidence from areas of biology which support and are explained by the theory of evolution, i.e. evidence from paleontology, comparative anatomy (homologous and analogous structures), embryology, comparative biochemistry, selective breeding and the geographical distribution of species.

Item Focus

The student should be able to explain the convergent evolution of marsupial and placental mammals.

Item

Refer to Figure 5K.9.

MAMMALS OF AUSTRALIA (LEFT) COMPARED WITH THOSE OF OTHER CONTINENTS

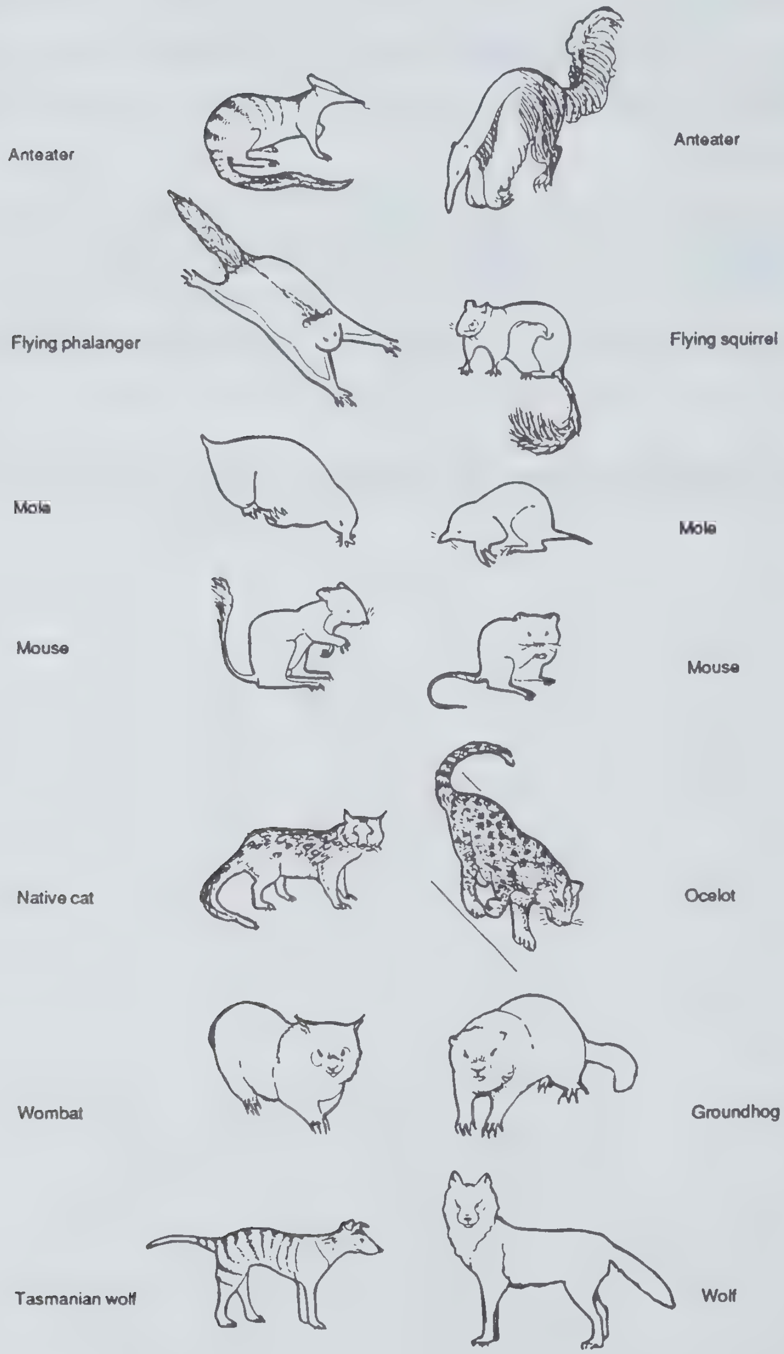


Figure 5K.9 shows pictures and common names of several genera of mammals from Australia (left column), and from the other continents (right column).

A. Account for the similarities in appearance between each of the unrelated pairs, that are classified in different genera.

B. What term is applied to the biological principle illustrated?

Response/Marking Scheme

A. The species of Australia occupy similar niches to those occupied by their counterparts from other continents. 1

(i.e., they are "ecological equivalents") 1

Consequently they have been shaped by similar forces of natural selection, so that they look and behave alike. 1

The Australian mammals have evolved in isolation from the other continents, 1

during the time when mammals were evolving. 1

Since the ancestral mammals, at the time of Australia's isolation, were quite different ("marsupials"), the groups that evolved to fill each niche in Australia are very different than on other continents. The different generic names reflect 1

their different ancestry. 1

B. The phenomenon is called "convergent evolution". 1

Possible: 8

Maximum: 5

Teacher Notes

DRAFT

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B051KaER.25
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 51Ka
UNIT NUMBER: 05	INSTRUMENT TYPE: ER
UNIT NAME: THEORY OF EVOLUTION	KLOPFER: A.1, A.2, A.3, A.5
	DIFFICULTY LEVEL: M
TOPIC: Natural Selection	TIME ALLOCATION:
CURRICULAR EMPHASIS: Nature of Science	

KEYWORDS: Kettlewell peppered moth melanism

Guideline Objective

Students will be expected to name and briefly describe the lines of evidence from areas of biology which support and are explained by the theory of evolution, i.e. evidence from paleontology, comparative anatomy (homologous and analogous structures), embryology, comparative biochemistry, selective breeding and the geographical distribution of species.

Item Focus

The student should be able to explain industrial melanism.

Item

Considering Kettlewell's experiments, explain how the peppered moth, *Biston betularia*, can exist in both mottled and dark (melanic) forms, and how the type that predominates in any particular area depends on the degree of industrial development in the area.

Response/Marking Scheme

All moths of that species have the gene that can mutate to produce dark pigment.	1
The distribution of pigment depends on another gene.	2
The normal moth has patches of black on a white background.	1
The melanic form has the gene for uniform distribution of pigment.	1
In normal populations, the melanic gene is frequently developing spontaneously by means of mutation.	2
The degree to which normal or melanic moths survive within a particular population depends on natural selection.	1
According to Kettlewell, the agents of selection are birds, which pluck exposed moths off tree trunks	2
where the moths remain at rest during the daylight.	1
In non-industrial areas, tree trunks have a mottled light and dark appearance, due to the growth of lichens.	2
Here, normal moths are less conspicuous than melanic	1
forms, and birds eat most melanic moths	1
before they can reproduce.	1
In industrial areas, sulphur dioxide in emissions kills lichens, which are particularly	2
sensitive to its toxic effects.	1
Also, soot may darken tree trunks.	1
Both cause uniformly dark tree trunks.	1
In this environment, birds prey selectively on normal forms,	1
so the melanic forms survive, reproduce, and pass on their melanic genes to the next generation.	1
Since the melanic gene is dominant, it is easily	1
maintained in the area even if migration of moths with normal genes occurs from the surrounding country.	1
Possible:	25
Maximum:	15

Teacher Notes

DRAFT

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B051KaER.26
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 51Ka
UNIT NUMBER: 05	INSTRUMENT TYPE: ER
UNIT NAME: THEORY OF EVOLUTION	KLOPFER: A.1, A.2, A.3, A.8, A.9
	DIFFICULTY LEVEL: M
TOPIC: Natural Selection	TIME ALLOCATION:
CURRICULAR EMPHASIS: Solid Foundations	

KEYWORDS: Kettlewell peppered moth

Guideline Objective

/tudents will be expected to name and briefly describe the lines of evidence from areas of biology which support and are explained by the theory of evolution, i.e., evidence from paleontology, comparative anatomy (homologous and analogous structures), embryology, comparative biochemistry, selective breeding and the geographical distribution of species.

Item Focus

The student should be able to describe the colour change in a population of peppered moths and explain it in terms of natural selection.

Item

Describe in detail the process of natural selection in terms of changes in the population of peppered moths, as a result of genetics and the environment.

Response/Marking Scheme

All peppered moths have the necessary gene to produce the dark pigment.	1
Another gene determines the distribution of pigment.	2
The normal moth has patches of black on a white background.	1
The melanic form has the gene for uniform distribution of pigment.	1
In normal populations, spontaneous mutation continually produces the gene for melanic distribution.	2
Natural selection determines the degree to which the normal or melanic forms will survive.	1
Kettlewell determined that birds are the agents of natural selection,	1
preying on moths that are at rest	1
exposed on tree trunks during the day.	1
In non-industrial areas, because of the growth of lichens, the tree trunks have a mottled light and dark appearance.	2
Here normal moths are less conspicuous than melanic forms,	1
and birds eat most melanic moths	1
before they can reproduce.	1
In industrial areas, sulphur dioxide in factory emissions kills lichens,	2
which are particularly sensitive to its toxic effects.	1
Also, soot may darken the tree trunks.	1
Both result in darkened tree trunks.	1
In this environment, birds prey selectively on normal forms,	1
and the melanic forms survive, reproduce, and pass their melanic genes on to the next generation.	1
Since the gene for melanic distribution is dominant, it is easily maintained in the population, even if migration brings moths with normal genes into the area.	2
Possible:	26
Maximum:	20
Quality:	2
Total:	22

Teacher Notes

DRAFT

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B051KaLA.01
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 51Ka
UNIT NUMBER: 05	INSTRUMENT TYPE: LA
UNIT NAME: THEORY OF EVOLUTION	KLOPFER: A.1, A.2, A.3, A.11, B.2, C.2.
	DIFFICULTY LEVEL: M
TOPIC: Natural Selection	TIME ALLOCATION:
CURRICULAR EMPHASIS: Nature of Science	

KEYWORDS: peppered moth hypothesis Kettlewell

Guideline Objective

Students will be expected to name and briefly describe the lines of evidence from areas of biology which support and are explained by the theory of evolution, i.e. evidence from paleontology, comparative anatomy (homologous and analogous structures), embryology, comparative biochemistry, selective breeding and the geographical distribution of species.

Item Focus

The student should be able to interpret field data of the peppered moth population.

Item

The following data were obtained by H. B. D. Kettlewell by trapping moths in England in the middle 1950's. The data reflect the populations of peppered moths in two regions.

Region	Number of moths caught	
	Light form	Dark form
Birmingham (industrial)	63	558
Dorset (rural)	297	17

A. What difference occurred in the populations of the two regions? Is the difference significant?

B. Suggest an hypothesis to account for the differences.

C. Describe the design of an experiment to test the hypothesis advanced in part B.

Response/Marking Scheme

A. In Birmingham, 90% of the moth population was dark, and only 10% light. In Dorset, 95% of the population was light, and only 5% dark. 2

By chance, one might expect the populations to be equally divided between the two forms. The difference is significant. 1

B. Hypothesis: natural selection is at work in changing populations in both regions. Predators effect this selection by consuming the more conspicuous moths, and leaving the better camouflaged moths to reproduce. 2

Colouration must be inherited, each succeeding generation of moths resembles their better camouflaged parents. 2

In Dorset, the air was cleaner, sweeping in from the Atlantic, and the lichens on the tree trunks was light grey, favouring the survival of light form moths. 2

In Birmingham, an industrial city, black soot from coal furnaces had coated the trees (killing the lichens), favouring the survival of the dark moths. 2

C. Trap a number of moths of both colour phases. 1

Mark the moths for later identification. 1

Release equal numbers of both colour phases in both locations. 1

Allow a few days for predation. 1

Recapture moths in both locations by trapping. 1

Analyze the data to assess the effect of predation on the populations in both locations. 1

Possible: 17

Maximum: 12

Quality: 2

Total: 14

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 05
UNIT NAME: THEORY OF EVOLUTION

TOPIC: Comparative Anatomy
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B051KaSA.01
GUIDELINE OBJECTIVE CODE: 51Ka
INSTRUMENT TYPE: SA
KLOPFER: A.1, A.2, A.3, A.4, A.5, A.6, A.9, C.1, C.2, D.3.
DIFFICULTY LEVEL: H
TIME ALLOCATION:

KEYWORDS: homology

Guideline Objective

Students will be expected to name and briefly describe the lines of evidence from areas of biology which support and are explained by the theory of evolution, i.e. evidence from paleontology, comparative anatomy (homologous and analogous structures), embryology, comparative biochemistry, selective breeding and the geographical distribution of species.

Item Focus

The student should be able to use knowledge of modifications to the structure of the respiratory system to support the theory of evolution.

Item

The respiratory system of mammals is not as efficient as that of birds. The fact that the lungs of mammals are blind-ended sacs necessitates the influx of new air to mix with outgoing waste air. In what ways does the structure of this system help support the theory of evolution?

Response/Marking Scheme

The mammalian respiratory system is a blind end set of tubes derived from the gut (endoderm) according to 1

embryological studies. Some lower vertebrates, including fish, especially the lung fish, and amphibians gulp air into the mouth and esophagus where exchange of gas is 1

possible. It is believed that lungs evolved from this practice, gradually forming a pocket in the gut that 1

expanded into alveolar structures common to terrestial 1

vertebrates. Natural selection leads to the change 1

in gene frequencies to develop these modifications, 1

within the limits of the basic design.

Possible: 6

Maximum: 5

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 05
UNIT NAME: THEORY OF EVOLUTION
TOPIC: Comparative Anatomy
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B051KaSA.02
GUIDELINE OBJECTIVE CODE: 51Ka
INSTRUMENT TYPE: SA
KLOPFER: A.1, A.2, A.3, A.4, A.5, A.6, A.9, D.2
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: homology

Guideline Objective

Students will be expected to name and briefly describe the lines of evidence from areas of biology which support and are explained by the theory of evolution, i.e. evidence from paleontology, comparative anatomy (homologous and analogous structures), embryology, comparative biochemistry, selective breeding and the geographical distribution of species.

Item Focus

The student should be able to identify homologous structures between different pairs of organisms to illustrate evolutionary relationships.

Item

Homology, revealed by studies of comparative anatomy, suggests that organisms may have shared common ancestors at some time in their evolutionary past.

For each of the following pairs of organisms, list one common homologous structure:

A. bird and whale

B. frog and snake

C. baboon and man

D. bat and cat

Response/Marking Scheme

Accept any one common structure from each pair, for 1 mark. such as the following:

A. heart, nervous system, lungs, dorsal nerve cord and brain, spinal cord.

B. lungs, 3-chambered heart, dorsal nerve cord and brain, vertebral column

C. well-developed brain with large cerebral cortex, opposable thumb, binocular vision

D. fur, mammary glands, placenta, vertebrate characters

Maximum: 4

Teacher Notes

DRAFT

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 05
UNIT NAME: THEORY OF EVOLUTION

TOPIC: Comparative Biochemistry
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B051KaSA.03
GUIDELINE OBJECTIVE CODE: 51Ka
INSTRUMENT TYPE: SA
KLOPFER: A.1, A.2, A.3, A.5, A.10.
DIFFICULTY LEVEL: M
TIME ALLOCATION:

KEYWORDS: amino acid sequence

Guideline Objective

Students will be expected to name and briefly describe the lines of evidence from areas of biology which support and are explained by the theory of evolution, i.e. evidence from paleontology, comparative anatomy (homologous and analogous structures), embryology, comparative biochemistry, selective breeding and the geographical distribution of species.

Item Focus

The student should be able to analyze differences in protein sequences to assess the closeness of relationships.

Item

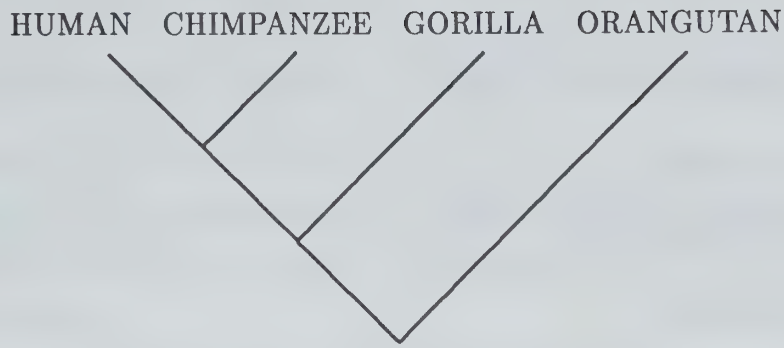
When proteins are analyzed for the sequence of their amino acids, some patterns emerge. Consider the hemoglobin molecule, consisting of two identical alpha chains of 141 amino acids, and two identical beta chains of 146 amino acids. The following table shows the number of different amino acid sites when the hemoglobin chains of several primates are compared with that of the human:

Animal	Number of different sites
chimpanzee	0
gorilla	1
orangutan	3

On the basis of the evidence, construct a "family tree" to show the probable relationships among humans and great apes. Explain your reasoning.

Response/Marking Scheme

Diagram: 3



Differences in amino acids of the hemoglobin molecule result from mutations which must have occurred after the species separated from a common ancestor. Therefore, the greater the difference, the longer two species have been separated. 2

Humans and chimpanzees have identical hemoglobin, and must have the most recent common ancestor, so the branching must be nearest the top of the tree. 2

Gorillas must be next closely related, the one different amino acid separating them from the human/chimp ancestor earlier in time. 1

The orangutan is most distant from the others. 1

Possible: 9

Maximum: 6

Teacher Notes

DRAFT

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 05
UNIT NAME: THEORY OF EVOLUTION

TOPIC: Natural Selection
CURRICULAR EMPHASIS: Nature of Science

INSTRUMENT CODE: B051KbMC.01
GUIDELINE OBJECTIVE CODE: 51Kb
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3, A.8, I.2
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: Darwin/Wallace

Guideline Objective

Students will be expected to state and explain the Darwin/Wallace theory of natural selection.

Item Focus

The student should be able to distinguish between Darwin's theory of the origin of species and the modern Neo-Darwinian theory of Evolution.

Item

Which of the following statements would **NOT** have been included in the theory of natural selection as proposed by Darwin and Wallace.

☐ A. All living things today have an ancestral species in the past.

☐ B. Evolution is directed by natural selection.

☐ C. Species have originated in the past and are still developing.

☐ D. Random inheritable variations are the "raw material" of the evolutionary process.

☐ E. Organisms are adapted to environmental conditions.

Response/Marking Scheme

Correct response: D

Teacher Notes

DRAFT

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B051KbMC.02
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 51Kb
UNIT NUMBER: 05	INSTRUMENT TYPE: MC
UNIT NAME: THEORY OF EVOLUTION	KLOPFER: A.1, A.2, A.3, A.8, I.3
	DIFFICULTY LEVEL: L
TOPIC: Natural Selection	TIME ALLOCATION:
CURRICULAR EMPHASIS: Nature of Science	

KEYWORDS: Darwin/Wallace

Guideline Objective

Students will be expected to state and explain the Darwin/Wallace theory of natural selection.

Item Focus

The student should be able to recognize components of Darwin's theory of natural selection.

Item

Natural selection, as described in the Darwin/Wallace mechanism of evolution, assumed that

- [ ] A. populations of animals are stable and unchanging.
- [ ] B. random differences provide some organisms greater survival value.
- [ ] C. environmentally acquired characteristics can be inherited.
- [ ] D. environmental stimuli result in changes in body structure.
- [ ] E. organisms perceive a need to change their characteristics to suit the environment.

Response/Marking Scheme

Correct response: B

Teacher Notes

DRAFT

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B051KbMC.04
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 51Kb
UNIT NUMBER: 05	INSTRUMENT TYPE: MC
UNIT NAME: THEORY OF EVOLUTION	KLOPFER: A.1, A.2, A.3, A.9
	DIFFICULTY LEVEL: L
TOPIC: Natural Selection	TIME ALLOCATION:
CURRICULAR EMPHASIS: Nature of Science	

KEYWORDS: Darwin/Wallace

Guideline Objective

Students will be expected to state and explain the Darwin/Wallace theory of natural selection.

Item Focus

The student should be able to identify the principal cause of natural selection.

Item

Darwin and Wallace contended that the principal cause of natural selection was

☐ A. the inheritance of acquired variations.

☐ B. genetic drift.

☐ C. the effect of factors in the environment.

☐ D. a mutation of the DNA

☐ E. the effect of one population of organisms on the reproductive capacity of another.

Response/Marking Scheme

Correct response: C

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 05
UNIT NAME: THEORY OF EVOLUTION

TOPIC: Natural Selection
CURRICULAR EMPHASIS: Nature of Science

INSTRUMENT CODE: B051KbMC.05
GUIDELINE OBJECTIVE CODE: 51Kb
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3, A.9
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: Wallace

Guideline Objective

Students will be expected to state and explain the Darwin/Wallace theory of natural selection.

Item Focus

The student should be able to identify the contribution of Wallace to evolutionary theory.

Item

Wallace contributed to the theory of natural selection by

☐ A. developing the laws of inheritance from his experiments with peas.

☐ B. writing to Charles Darwin for Darwin's reaction to a new theory that Wallace had developed.

☐ C. developing the Hardy/Weinberg equation for population genetics.

☐ D. working out the relationships among the different finches of the Galapagos Islands.

☐ E. establishing the geological principle of uniformity, on which the fossil record was worked out.

Response/Marking Scheme

Correct response: B

Teacher Notes

DRAFT

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B051KbMC.06
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 51Kb
UNIT NUMBER: 05	INSTRUMENT TYPE: MC
UNIT NAME: THEORY OF EVOLUTION	KLOPFER: A.1, A.3, A.9, B.2, I.1, I.3
	DIFFICULTY LEVEL: M
TOPIC: Natural Selection	TIME ALLOCATION:
CURRICULAR EMPHASIS: Nature of Science	

KEYWORDS: Darwin/Wallace

Guideline Objective

Students will be expected to state and explain the Darwin/Wallace theory of natural selection.

Item Focus

The student should be able to identify the observations upon which the Darwin/Wallace theory is based, and distinguish them from inferences.

Item

The theory of natural selection, proposed by Darwin and Wallace in 1858 was based upon certain observations. Which of the following statements were <u>observations</u>, as distinguished from <u>inferences</u> (conclusions)?

I Within each species, organisms vary in many traits.

II Many of the varied traits are inheritable from parents to their offspring.

III Reproduction usually results in more offspring than the environment can support, yet each population generally remains remarkably stable, generation after generation.

IV Competition occurs at every generation for food, shelter, living space, and mates. In this competition, only the better-adapted members of each population survive to produce offspring.

V At every generation, natural agencies (predators, parasites, disease, starvation, environmental extremes) select the better-adapted traits, gradually changing the population.

Select your answer from

☐ A. I, II, III, IV, and V.

☐ B. I, II, and III only.

☐ C. III, IV, and V only.

☐ D. I, III, and IV only.

☐ E. IV and V only.

Response/Marking Scheme

Correct response: B

Teacher Notes

DRAFT

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B051KbMC.07
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 51Kb
UNIT NUMBER: 05	INSTRUMENT TYPE: MC
UNIT NAME: THEORY OF EVOLUTION	KLOPFER: A.1, A.3, A.9, B.2, I.1, I.3
	DIFFICULTY LEVEL: M
TOPIC: Natural Selection	TIME ALLOCATION:
CURRICULAR EMPHASIS: Nature of Science	

KEYWORDS: Darwin/Wallace

Guideline Objective

Students will be expected to state and explain the Darwin/Wallace theory of natural selection.

Item Focus

The student should be able to identify the observations upon which the Darwin/Wallace theory is based, and distinguish them from inferences.

Item

The theory of natural selection, proposed by Darwin and Wallace in 1858 was based upon certain observations. Which of the following statements were inferences, (conclusions) as distinguished from observations?

I Within each species, organisms vary in many traits.

II Many of the varied traits are inheritable from parents to their offspring.

III Reproduction usually results in more offspring than the environment can support, yet each population generally remains remarkably stable, generation after generation.

IV Competition occurs at every generation for food, shelter, living space, and mates. In this competition, only the better-adapted members of each population survive to produce offspring.

V At every generation, natural agencies (predators, parasites, disease, starvation, environmental extremes) select the better-adapted traits, gradually changing the population.

Select your answer from

☐ A. I, II, III, IV, and V.

☐ B. I, II, and III only.

☐ C. III, IV, and V only.

☐ D. I, III, and IV only.

☐ E. IV and V only.

Response/Marking Scheme

Correct response: E

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B051KbMC.08
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 51Kb
UNIT NUMBER: 05	INSTRUMENT TYPE: MC
UNIT NAME: THEORY OF EVOLUTION	KLOPFER: A.1, A.2, A.3, A.9
	DIFFICULTY LEVEL: L
TOPIC: Natural Selection	TIME ALLOCATION:
CURRICULAR EMPHASIS: Nature of Science	

KEYWORDS:

Guideline Objective

Students will be expected to state and explain the Darwin/Wallace theory of natural selection.

Item Focus

The student should be able to identify the agent of natural selection.

Item

Natural selection in a population results from the action of

☐ A. mutations.

☐ B. point substitution.

☐ C. the environment.

☐ D. transcription.

☐ E. evolution.

Response/Marking Scheme

Correct response: C

Teacher Notes

DRAFT

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 05
UNIT NAME: THEORY OF EVOLUTION

TOPIC: Natural Selection
CURRICULAR EMPHASIS: Nature of Science

INSTRUMENT CODE: B051KbMC.09
GUIDELINE OBJECTIVE CODE: 51Kb
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3, A.9
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: adaptation

Guideline Objective

Students will be expected to state and explain the Darwin/Wallace theory of natural selection.

Item Focus

The student should be able to identify an aspect of the theory of natural selection.

Item

In Darwin's theory, natural selection implies that

☐ A. acquired characteristics play no role in evolution.

☐ B. acquired characteristics are not inherited.

☐ C. the best adapted individuals will generally produce the greatest number of offspring.

☐ D. the best adapted individuals will not have to struggle for existence.

☐ E. animals that live on islands have the best chance to become new species.

Response/Marking Scheme

Correct response: C

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 05
UNIT NAME: THEORY OF EVOLUTION

TOPIC: Natural Selection
CURRICULAR EMPHASIS: Nature of Science

INSTRUMENT CODE: B051KbMC.10
GUIDELINE OBJECTIVE CODE: 51Kb
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3, A.8
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: Darwin/Wallace

Guideline Objective

Students will be expected to state and explain the Darwin/Wallace theory of natural selection.

Item Focus

The student should be able to identify the assumption on which the theory of natural selection is based.

Item

Natural selection, as described in Darwin's and Wallace's view of evolution, assumed

☐ A. a stable and unchanging population of organisms.

☐ B. greater reproductive potential of some random differences.

☐ C. the inheritance of environmentally acquired characteristics.

☐ D. that environmental stimuli produce changes in body structure.

☐ E. that organisms change in response to needs that they perceive.

Response/Marking Scheme

Correct response: B

Teacher Notes

DRAFT

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 05
UNIT NAME: THEORY OF EVOLUTION

TOPIC: Natural Selection
CURRICULAR EMPHASIS: Nature of Science

INSTRUMENT CODE: B051KbMC.11
GUIDELINE OBJECTIVE CODE: 51Kb
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3, A.8
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: Darwin/Wallace

Guideline Objective

Students will be expected to state and explain the Darwin/Wallace theory of natural selection.

Item Focus

The student should be able to identify the likely reason for many structural similarities between two species.

Item

When two animals of different species show many structural similarities, it is probably because these two species

☐ A. lived in different environments for a long time.

☐ B. are genetically related to a common ancestor.

☐ C. share characteristics and perform different functions.

☐ D. have passed through a period of adaptation.

☐ E. became similar by chance.

Response/Marking Scheme

Correct response: B

Teacher Notes

DRAFT

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B051KbMC.12
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 51Kb
UNIT NUMBER: 05	INSTRUMENT TYPE: MC
UNIT NAME: THEORY OF EVOLUTION	KLOPFER: A.1, A.2, A.3
	DIFFICULTY LEVEL: L
TOPIC: Natural Selection	TIME ALLOCATION:
CURRICULAR EMPHASIS: Nature of Science	

KEYWORDS: Darwin/Wallace

Guideline Objective

Students will be expected to state and explain the Darwin/Wallace theory of natural selection.

Item Focus

The student should be able to identify factors involved in natural selection.

Item

In the course of evolution, natural selection depends mostly on

- ☐ A. intelligence.
- ☐ B. reproductive success.
- ☐ C. mutations.
- ☐ D. life expectancy.
- ☐ E. effort and need.

Response/Marking Scheme

Correct response: B

Teacher Notes

DRAFT

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 05
UNIT NAME: THEORY OF EVOLUTION

TOPIC: Natural Selection
CURRICULAR EMPHASIS: Nature of Science

INSTRUMENT CODE: B051KbMC.13
GUIDELINE OBJECTIVE CODE: 51Kb
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3, A.9
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: Darwin/Wallace

Guideline Objective

Students will be expected to state and explain the Darwin/Wallace theory of natural selection.

Item Focus

The student should be able to identify the theory of natural selection.

Item

Natural selection, as Darwin and Wallace described it, assumed

☐ A. a stable, unchanging population of organisms.

☐ B. changes from generation to generation by mutation.

☐ C. environmental stimuli causing changes in body structure in successive generations of offspring.

☐ D. different survival rates among offspring with random variations.

☐ E. might is right: the strong will overcome the weak.

Response/Marking Scheme

Correct response: D

Teacher Notes

DRAFT

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 05
UNIT NAME: THEORY OF EVOLUTION

TOPIC: Natural Selection
CURRICULAR EMPHASIS: Nature of Science

INSTRUMENT CODE: B051KbMC.14
GUIDELINE OBJECTIVE CODE: 51Kb
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3, A.9
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: extinction

Guideline Objective

Students will be expected to state and explain the Darwin/Wallace theory of natural selection.

Item Focus

The student should be able to identify aspects of natural selection.

Item

The extinction of a species is most likely due to

☐ A. the effect of the ice ages.

☐ B. the failure to interbreed with better adapted species.

☐ C. the inability to adapt to changing environments.

☐ D. the inability to cross geographical barriers.

☐ E. alterations of its genetic code.

Response/Marking Scheme

Correct response: C

Teacher Notes

DRAFT

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 05
UNIT NAME: THEORY OF EVOLUTION

TOPIC: Natural Selection
CURRICULAR EMPHASIS: Nature of Science

INSTRUMENT CODE: B051KbMC.15
GUIDELINE OBJECTIVE CODE: 51Kb
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3, A.9
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: Darwin/Wallace

Guideline Objective

Students will be expected to state and explain the Darwin/Wallace theory of natural selection.

Item Focus

The student should be able to identify a definition of evolution.

Item

Which one of the following would NOT be described as evolution?

☐ A. The adjustment of an individual to changed environmental conditions.

☐ B. The gradual change in the characteristics of a species over the course of many generations.

☐ C. The formation of two or more species from one ancestral species.

☐ D. The theory that all organisms may be descended from one or a few common ancestors.

☐ E. The changes in the gene pool of a population through recombination, mutation, and natural selection.

Response/Marking Scheme

Correct response: A

Teacher Notes

DRAFT

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B051KbER.01
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 51Kb
UNIT NUMBER: 05	INSTRUMENT TYPE: ER
UNIT NAME: THEORY OF EVOLUTION	KLOPFER: A.1, A.2, A.3, A.5.
	DIFFICULTY LEVEL: M
TOPIC: Darwin/Wallace theory	TIME ALLOCATION:
CURRICULAR EMPHASIS: Nature of Science	

KEYWORDS: Darwin/Wallace

Guideline Objective

Students will be expected to state and explain the Darwin/Wallace theory of natural selection.

Item Focus

The student should be able to hypothesize about a classic conundrum in terms of the Darwin/Wallace theory.

Item

"Which came first, the chicken, or the egg?"

Use your knowledge of the Theory of Descent with Modification of Darwin and Wallace to discuss the conundrum above.

Response/Marking Scheme

Before there were chickens, there were eggs. The ancestor of the modern chicken was a chicken-like jungle fowl.	2
Many small modifications (mutations) were selected by nature and by humans as the jungle fowl evolved into a chicken.	2
The ancestor of the jungle fowl was a more primitive bird, that hatched from an egg. Thus eggs came before chickens.	2
If we trace the ancestry far enough back, we find creatures that are as much reptile as bird, something like *Archeopteryx*. They still hatched from eggs.	2
Possible:	8
Maximum:	5

Teacher Notes

DRAFT

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B051KbER.02R
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 51Kb
UNIT NUMBER: 05	INSTRUMENT TYPE: ER
UNIT NAME: THEORY OF EVOLUTION	KLOPFER: A.1, A.2, A.3, A.8, A.9, A.10, F.1
TOPIC: Natural Selection	DIFFICULTY LEVEL: H
CURRICULAR EMPHASIS: Nature of Science	TIME ALLOCATION:

KEYWORDS: adaptation taxonomy

Guideline Objective

Students will be expected to state and explain the Darwin/Wallace theory of natural selection.

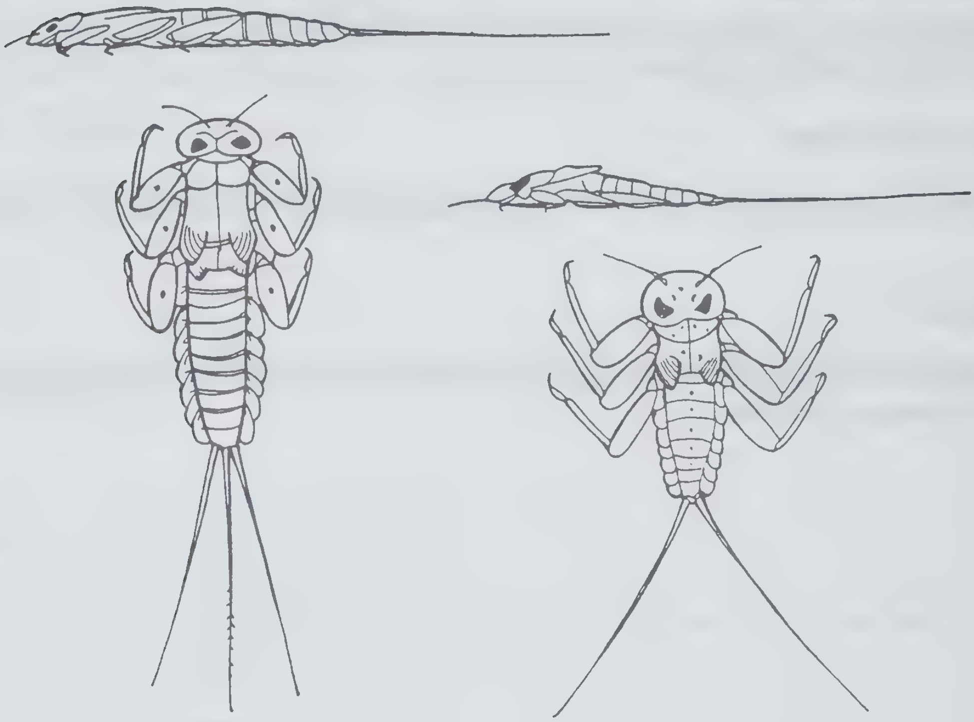
Item Focus

The student should be able to account for similar adaptations on different continents in terms of convergent evolution.

Item

Refer to Figure 5K.10.

NYMPHS OF TWO SPECIES OF MAYFLIES



Rhithrogena (Europe) *Epeorus* (N. America)

Figure 5K.10 shows the dorsal and side views of the nymphs of two species of mayflies, both of which are adapted to live on rocks lying in swiftly flowing streams. They are, however, from different continents.

Taxonomists (specialists in classification) place them both in the same family, but in different genera. Most people, however, on seeing them, would think they belong in the same genus.

Using ecological and/or evolutionary arguments, account for this mistake in classification that most non-specialists would be likely to make.

Response/Marking Scheme

A close relationship is suggested by very similar anatomy and morphology,	1
aside from the superficial differences in size.	1
Convergent evolution could account for the similarities.	1
Each is adapted to cling to the surface of a rock, while being subjected to the considerable force of flowing water.	1
By being streamlined, their structure allows water to flow over them easily.	1
The ability to fold their legs in such a way as to prevent water from flowing between their body and the rock helps to prevent them from being swept away.	1
Natural selection over hundreds of generations has removed from the gene pool individuals with these traits less well developed.	1
Random mutation, and	1
random assortment and recombination of existing alleles	1
has helped develop individuals with better adaptation	1
that would be less likely to be swept by the current into the mouths of predatory fish.	1
These individuals would be more likely to survive to adulthood, and to	1
pass their favourable mutations/combinations of alleles to the following generation.	1
Thus the environment of swift water and exposed surfaces shaped two ancestral types from different gene pools into similarly adapted species.	1
Possible:	14
Maximum:	10

Teacher Notes

DRAFT

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B051KbSA.01
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 51Kb
UNIT NUMBER: 05	INSTRUMENT TYPE: SA
UNIT NAME: THEORY OF EVOLUTION	KLOPFER: A.1, A.3, A.9, B.2, I.1, I.3
	DIFFICULTY LEVEL: M
TOPIC: Natural Selection	TIME ALLOCATION:
CURRICULAR EMPHASIS: Nature of Science	

KEYWORDS: Darwin/Wallace

Guideline Objective

Students will be expected to state and explain the Darwin/Wallace theory of natural selection.

Item Focus

The student should be able to state the observations upon which the Darwin/Wallace theory is based, and state the inferences that arise from them.

Item

The theory of natural selection, proposed by Darwin and Wallace in 1858, was based upon certain observations.

A. State four observations upon which the theory was based.

B. What are the three inferences (conclusions) that Darwin and Wallace drew from the observations listed in A?

Response/Marking Scheme

A.	Within each species, organisms vary in many traits.	1
	Many of the varied traits are inheritable from parents to their offspring.	1
	Reproduction usually results in more offspring than	1
	the environment can support. The population of each species remains remarkably stable, generation after generation.	1
B.	Competition occurs during every generation for food, shelter, living space, and mates.	2
	In this competition, only the better-adapted members of each population survive to produce offspring.	2
	At every generation, natural agencies (predators, parasites, disease, starvation, environmental extremes) select individuals possessing the better-adapted	1
	traits, gradually changing the population.	1
	Possible:	10
	Maximum:	7

Teacher Notes

DRAFT

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B051KbSA.02
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 51Kb
UNIT NUMBER: 05	INSTRUMENT TYPE: SA
UNIT NAME: THEORY OF EVOLUTION	KLOPFER: A.1, A.2, A.3
	DIFFICULTY LEVEL: M
TOPIC: Natural Selection	TIME ALLOCATION:
CURRICULAR EMPHASIS: Nature of Science	

KEYWORDS: gene pool

Guideline Objective

Students will be expected to state and explain the Darwin/Wallace theory of natural selection.

Item Focus

The student should be able to identify factors involved in natural selection.

Item

Comment on the following: Evolution may be explained as the result of the environment's effect in determining the ability of different phenotypes to survive.

Response/Marking Scheme

This statement is <u>true in part</u>, but it is more than just the ability of <u>different phenotypes</u> to survive.	3
The adaptive phenotype must be determined by a genotype that is inheritable.	1
The adaptive alleles must increase in the population	1
gene pool by differential reproduction.	2
Possible:	7
Maximum:	5

Teacher Notes

DRAFT

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B051KcMC.01
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 51Kc
UNIT NUMBER: 05	INSTRUMENT TYPE: MC
UNIT NAME: THEORY OF EVOLUTION	KLOPFER: A.1, A.2, A.3, A.8, I.3
	DIFFICULTY LEVEL: L
TOPIC: Origin of Species	TIME ALLOCATION:
CURRICULAR EMPHASIS: Nature of Science	

KEYWORDS: Lamarck Darwin

Guideline Objective

Students will be expected to compare Darwin's theory of the origin of species with that proposed by Lamarck.

Item Focus

The student should be able to recognize similarities among the ideas of Lamarck and Darwin.

Item

Both Lamarck and Darwin

☐ A. are responsible for the origin of the idea of organic evolution.

☐ B. attempted to explain mutation.

☐ C. attempted to explain the mechanisms of evolution.

☐ D. believed that organisms do not change.

☐ E. extended Mendel's work in genetics.

Response/Marking Scheme

Correct response: C

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B051KcMC.02
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 51Kc
UNIT NUMBER: 05	INSTRUMENT TYPE: MC
UNIT NAME: THEORY OF EVOLUTION	KLOPFER: A.1, A.2, A.3, A.8, I.3
	DIFFICULTY LEVEL: M
TOPIC: Origin of Species	TIME ALLOCATION:
CURRICULAR EMPHASIS: Nature of Science	

KEYWORDS: Lamarck Darwin

Guideline Objective

Students will be expected to compare Darwin's theory of the origin of species with that proposed by Lamarck.

Item Focus

The students should be able to recognize differences between the theories of Darwin and Lamarck.

Item

The following are statements which relate to different theories of evolution:

I A bird develops very strong wing muscles and as a result, its offspring also have well-developed muscles.

II Many field mice are caught by hawks and owls but some are fast enough to escape. Over several generations, the number of mice caught by hawks and owls decreases.

III There are more butterflies of a particular colour pattern in an area because the colours blend in with the surrounding vegetation.

IV Succeeding generations of cheetahs have become increasingly faster because of a need to capture fast moving prey.

V All living things on earth are here as a result of descent, with modification, from a common ancestor.

Which of the above statements are in keeping with the Darwinian view of evolution?

☐ A. I, II, and V only.

☐ B. II, III, and V only.

☐ C. I and IV only.

☐ D. II and III only.

☐ E. III, IV, and V only.

Response/Marking Scheme

Correct response: B

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B051KcMC.03
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 51Kc
UNIT NUMBER: 05	INSTRUMENT TYPE: MC
UNIT NAME: THEORY OF EVOLUTION	KLOPFER: A.1, A.2, A.3, A.8, I.3
	DIFFICULTY LEVEL: M
TOPIC: Origin of Species	TIME ALLOCATION:
CURRICULAR EMPHASIS: Nature of Science	

KEYWORDS: Lamarck

Guideline Objective

Students will be expected to compare Darwin's theory of the origin of species with that proposed by Lamarck.

Item Focus

The students should be able to recognize differences between the theories of Darwin and Lamarck.

Item

The following are statements which relate to different theories of evolution:

I A bird develops very strong wing muscles and as a result, its offspring also have well-developed muscles.

II Many field mice are caught by hawks and owls but some are fast enough to escape. Over several generations, the number of mice caught by hawks and owls decreases.

III There are more butterflies of a particular colour pattern in an area because the colours blend in with the surrounding vegetation.

IV Succeeding generations of cheetahs have become increasingly faster because of a need to capture fast moving prey.

V All living things on earth are here as a result of descent, with modification, from a common ancestor.

Which of the above statements are in keeping with the Lamarckian view of evolution?

☐ A. I, II, and V only.

☐ B. II, III, and V only.

☐ C. I and IV only.

☐ D. II and III only.

☐ E. III, IV, and V only.

Response/Marking Scheme

Correct response: C

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 05
UNIT NAME: THEORY OF EVOLUTION

TOPIC: Origin of Species
CURRICULAR EMPHASIS: Nature of Science

INSTRUMENT CODE: B051KcMC.04
GUIDELINE OBJECTIVE CODE: 51Kc
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: Lamarck

Guideline Objective

Students will be expected to compare Darwin's theory of the origin of species with that proposed by Lamarck.

Item Focus

The student should be able to identify Lamarck's concept of inheritance.

Item

Lamarck would have explained the long neck of the giraffe by claiming that

☐ A. the long neck appeared as a result of selective interbreeding among giraffes.

☐ B. the long necks appeared as a result of a mutation.

☐ C. only the longer necked giraffes survived, because they had an advantage in their environment.

☐ D. the need for a longer neck resulted in a longer neck that could be inherited.

☐ E. the longer necked giraffes appeared suddenly, by chance.

Response/Marking Scheme

Correct response: D

Teacher Notes

DRAFT

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 05
UNIT NAME: THEORY OF EVOLUTION

TOPIC: Neo-Darwinian Theory
CURRICULAR EMPHASIS: Nature of Science

INSTRUMENT CODE: B051KcMC.05
GUIDELINE OBJECTIVE CODE: 51Kc
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3, A.8, I.2
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: Darwin species natural selection

Guideline Objective

Students will be expected to compare Darwin's theory of the origin of species with that proposed by Lamarck.

Item Focus

The student should be able to distinguish between Darwin's theory of the origin of species and the modern Neo-Darwinian theory of Evolution.

Item

Which of the following statements would NOT have been part of Charles Darwin's theory?

☐ A. All living things today have an ancestral species in the past.

☐ B. Evolution is directed by natural selection.

☐ C. Species have originated in the past and are still developing.

☐ D. Random inheritable variations are the "raw material" of the evolutionary process.

☐ E. Organisms develop special adaptations in response to environmental conditions.

Response/Marking Scheme

Correct response: D

Teacher Notes

DRAFT

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 05
UNIT NAME: THEORY OF EVOLUTION

TOPIC: Lamarck's Theory
CURRICULAR EMPHASIS: Nature of Science

INSTRUMENT CODE: B051KcMC.06
GUIDELINE OBJECTIVE CODE: 51Kc
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3, A.9
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: Lamarck

Guideline Objective

Students will be expected to compare Darwin's theory of the origin of species with that proposed by Lamarck.

Item Focus

The student should be able to identify the kind of example that would support Lamarck's theory of inheritance.

Item

Lamarck's theory of evolution would be supported if data showed that short-necked chickens, fed from high feeders,

☐ A. produced offspring with long and short necks in equal numbers.

☐ B. produced offspring with short necks only.

☐ C. showed no change in their own necks, but produced offspring with longer necks.

☐ D. gradually developed longer necks and produced offspring with longer necks.

☐ E. produced offspring in the ratio of three long-necked to one short-necked.

Response/Marking Scheme

Correct response: D

Teacher Notes

DRAFT

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B051KcEE.01R
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 51Kc
UNIT NUMBER: 05	INSTRUMENT TYPE: EE
UNIT NAME: THEORY OF EVOLUTION	KLOPFER: A.1, A.2, A.3, A.5, A.9
	DIFFICULTY LEVEL: H
TOPIC: Darwin and Lamarck	TIME ALLOCATION:
CURRICULAR EMPHASIS: Nature of Science	

KEYWORDS: natural selection acquired characteristics

Guideline Objective

Students will be expected to compare Darwin's theory of the origin of species with that proposed by Lamarck.

Item Focus

The student should be able to describe and differentiate between the theories of Darwin, Lamarck and current evolutionists for the mechanics involved in species adaptation that leads to evolutionary change.

Item

Refer to Figure 5K.11.

THE FLAMINGO

The flamingo possesses an unusual morphology and posture (see Figure 5K.11) in order to facilitate a habit of feeding with its head upside down. The beak has a peculiar curve resulting in a hump creating a trough. The jaw itself has an unusual joint structure by which the upper jaw can move against a more stable lower jaw. The tongue is very fleshy and large to facilitate a filter feeding mechanism.

This is only one of many examples in which the form of a structure is adapted to its function.

A. How would Darwin have explained how such unusual structures arise?

B. How would Lamarck have explained how such unusual structures arise?

C. How would current evolutionists explain how such unusual structures arise?

Response/Marking Scheme

A. Darwin

Evolutionary change began with a change in feeding habits 1

of the pre-flamingo, perhaps as a result of competition 1

for food. The flamingo began to feed in hostile hypersaline 1

pools where little food of substantial size could be found. 1

Adequate quantities of food could be obtained by drawing in copious quantities of water and then filtering out the 1

edible organisms. Those members of the population that were better adapted 1

for this activity were better able to survive, that is, those animals with a large muscular tongue and a bill capable of digging and accommodating large quantities of 1

water. If the bird could reach down and underneath the feet, where edible delicacies had been stirred up, more prey could be obtained. 1

Through the process of natural selection, those better adapted birds would live long enough to reproduce, passing 1

some of these features on to the next generation where a 1

new round of selection would fine-tune the adaptive feature. 1

B. Lamarck

Evolutionary change began with a change in feeding habits 1

of the pre-flamingo, perhaps as a result of competition 1

for food.The flamingo began to feed in hostile hypersaline 1

pools where little food of substantial size could be found. 1

The flamingo needed to make morphological changes to 1

develop the feeding habits necessary for survival in this hostile environment. 1

The flamingo developed a thick muscular tongue, a large 1

curved beak and the ability to reach down and under the 1

feet for obtaining necessary quantities of small organisms in response to this need. 1

These changes were passed on to offspring. 1

In other words, the environment moulded the flamingo into 1

an organism that could function in the new environment and 1

these changes were hereditary and remain stable until 1

a new environment is encountered. This is the theory of acquired characteristics. 1

C. Modern Theory

Change that leads to a new species begins in the original 1

population of pre-flamingos. Within the population is considerable genetic variablility (heterozygosity). 1

There are multiple alleles including hidden recessives. 1

There are gene families (multiple copies of genes). 1

There are controlling genes and repressing genes. There 2

are combinations of genes that are responsible for a specific end product. 1

A portion of the original pre-flamingo population became an isolated founding population with 1

a distinct random sample of alleles (Genetic Drift). 1

This population interbred, exposing recessive alleles that may or may not have contributed to its survival. That is, 1

some of the genes may have enhanced the survival of the individual, some genes may have been lethal, and some may 1

have had no influence at all. This in itself can lead 1

to a huge change in phenotype. 1

Over time, those genes that contributed to enhanced survival increased in frequency. 1

If they are important for survival, they resist much mutational change. If they are relatively unimportant, 1

they will continue to provide for even more variation within the gene pool. 1

This provides even more raw material for natural selection to meet future changes. 1

It is also thought that the environment itself may influence the expression of a gene. Genes have controlling units that turn genes on and off. The control units could turn 1

some genes on that produce more beneficial end-products and turn off others that are more deleterious. Also, since 1

genes often occur in families that themselves exhibit a great deal of heterozygosity, different genes within the family may be selected by the environment for transcription and translation. 2

The environment may also play a role in the creation of mutations that lead to even greater variation. But this variation is at random and not associated with producing adaptive phenotypic traits. 1

In this way, the genetics of the founding population would be the new raw material for further selection that results in the fine tuning of the morphology of the population for the functions it requires for survival. 1

Possible: 48

Maximum: 22

Quality: 3

Total: 25

(Reference: Stephen Jay Gould, *Natural History.* March, 1985)

Teacher Notes

DRAFT

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B051KcER.01
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 51Kc
UNIT NUMBER: 05	INSTRUMENT TYPE: ER
UNIT NAME: THEORY OF EVOLUTION	KLOPFER: A.1. A.2, A.3, A.9
	DIFFICULTY LEVEL: H
TOPIC: Origin of Species	TIME ALLOCATION:
CURRICULAR EMPHASIS: Nature of Science	

KEYWORDS: Lamarck Darwin/Wallace genotype phenotype

Guideline Objective

Students will be expected to compare Darwin's theory of the origin of species with that proposed by Lamarck.

Item Focus

The student should be able to distinguish between the Lamarck and the Darwin/Wallace theories on the basis of genetics.

Item

Using the terms genotype and phenotype as the basis of your discussion, distinguish between the Lamarckian and the Darwin/Wallace theories of evolution.

Response/Marking Scheme

Phenotypes are the visible characters or traits that distinguish an individual.	2
Genotypes are the actual genes or alleles that an individual carries in each nucleus, and transmits through the gametes to the offspring.	2
Lamarck saw individuals developing traits during their lifetimes, and	1
passing these acquired phenotypes on to their offspring.	1
Genotypes are not developed this way, and are not	1
affected by the individual's development.	1
Thus Lamarck's theory has been discredited. Darwin and Wallace saw nature selecting from the pool of phenotypes in a population,	1
allowing those individuals that were more fit, in terms of	1
reproducing differentially, to leave more offspring.	2
Although they did not know it, these phenotypes reflected differences in genotype, which were being selected at the same time.	2
Possible:	14
Maximum:	10

DRAFT

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 05
UNIT NAME: THEORY OF EVOLUTION

TOPIC: Origin of Species
CURRICULAR EMPHASIS: Nature of Science

INSTRUMENT CODE: B051KcER.02
GUIDELINE OBJECTIVE CODE: 51Kc
INSTRUMENT TYPE: ER
KLOPFER: A.1, A.2, A.3, A.9, I.3
DIFFICULTY LEVEL: H
TIME ALLOCATION:

KEYWORDS: Lamarck Darwin Wallace

Guideline Objective

Students will be expected to compare Darwin's theory of the origin of species with that proposed by Lamarck.

Item Focus

The student should be able to explain the origin and distribution of the lungfishes using both the Lamarckian and the Darwinian theories of inheritance and natural selection.

Item

The lungfishes have an air-breathing "lung" connected to their mouth cavity. Living members of the group occur in Australia, central Africa, and South America. On each of these continents, they are confined to a very few rivers. Fossil lungfishes have been found in rocks all over the world.

A. Suggest how Lamarck would have explained the origin of the lungfishes.

B. How would Darwin or Wallace have explained the origin of the lungfishes?

C. Suggest hypotheses to explain

   1. why lungfishes are so widely distributed around the world, and

   2. why lungfishes occur in such a very few rivers on each of the continents where they live.

Response/Marking Scheme

A. Lamarckian explanation:

Lungfish needed or wanted to be able to breathe air when the rivers dried up, 1

so they developed a lung and a windpipe to meet the need, 1

and these were inherited by their offspring. 1

B. Some fishes have a connection from their throats to their swim bladders. Such fish can use the air in 1

their swim bladder for gas exchange to and from the blood in the capillaries lining the bladders. 1

When the rivers dried up, such fishes were able to move from pool to pool along the riverbed, to find 1

places to survive until the river filled with water again. The ability to use the swim bladder as a "lung" thus gave them a survival advantage in their environment. 1

Over many generations, the more efficient survivors reproduced, passing their advantage to their offspring. Thus the lungfish developed. 1

C.

1. The present world distribution of lungfishes reflects their past worldwide distribution. 1

Unsuitable environments have caused lungfishes to die in other parts of the world, 1

while favouring their survival in the three areas where their adaptation is still advantageous. 1

2. On each continent where lungfishes survive, their narrow distribution limits them to the few rivers in which their adaptation gives them an advantage over 1

other kinds of fishes. Perhaps there are barriers that prevent their spreading to other rivers. 1

Such barriers might include the inability to pass from one river to another by way of the ocean, if they cannot survive in salt water. 1

Or perhaps there are predators in the ocean against which they have no protection. 1

Possible: 15

Maximum: 10

Quality: 2

Total: 12

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 05
UNIT NAME: THEORY OF EVOLUTION

TOPIC: Natural Selection
CURRICULAR EMPHASIS: Nature of Science

INSTRUMENT CODE: B051KdMC.02
GUIDELINE OBJECTIVE CODE: 51Kd
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3, A.8, I.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: Darwin

Guideline Objective

Students will be expected to, including reference to Erasmus Darwin, Malthus, Lyell and the voyage of the HMS *Beagle*, describe briefly how Charles Darwin gathered evidence and developed his ideas.

Item Focus

The student should be able to recognize components of Darwin's theory of natural selection.

Item

Darwin based much of his theory of natural selection on

☐ A. the struggle for survival.

☐ B. mutations.

☐ C. environmentally acquired characteristics.

☐ D. the use and disuse of organs.

☐ E. the gene theory of inheritance.

Response/Marking Scheme

Correct response: A

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B051KdMC.03
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 51Kd
UNIT NUMBER: 05	INSTRUMENT TYPE: MC
UNIT NAME: THEORY OF EVOLUTION	KLOPFER: A.1, A.2, A.3, A.8
	DIFFICULTY LEVEL: L
TOPIC: Natural Selection	TIME ALLOCATION:
CURRICULAR EMPHASIS: Nature of Science	

KEYWORDS: Malthus

Guideline Objective

Students will be expected to, including reference to Erasmus Darwin, Malthus, Lyell and the voyage of the HMS *Beagle*, describe briefly how Charles Darwin gathered evidence and developed his ideas.

Item Focus

The student should be able to identify the contribution of Malthus to the theory of natural selection.

Item

Thomas Malthus influenced the ideas of both Darwin and Wallace with his observation that

☐ A. unusual types of organisms often inhabit islands.

☐ B. the organisms of Australia strongly resemble those of North America.

☐ C. in nature, only the best adapted organisms survive.

☐ D. populations increase geometrically, while food supplies do not.

☐ E. differential reproduction leads to success in evolution.

Response/Marking Scheme

Correct response: D

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 05
UNIT NAME: THEORY OF EVOLUTION

TOPIC: Darwin's Theory
CURRICULAR EMPHASIS: Nature of Science

INSTRUMENT CODE: B051KdER.01
GUIDELINE OBJECTIVE CODE: 51Kd
INSTRUMENT TYPE: ER
KLOPFER: A.1, A.2, A.3, I.3
DIFFICULTY LEVEL: M
TIME ALLOCATION:

KEYWORDS: Darwin Galapagos Islands

Guideline Objective

Students will be expected to, including reference to Erasmus Darwin, Malthus, Lyell and the voyage of the HMS *Beagle*,describe briefly how Charles Darwin gathered evidence and developed his ideas.

Item Focus

The student should be able to describe the significance of Darwin's observations of the birds of the Galapagos in the development of his theory.

Item

State the significance of the Galapagos Islands in the formation of Darwin's Theory of Evolution.

Response/Marking Scheme

The Galapagos Islands provided Darwin with the	1
evidence he required to formulate his theory on the origin of species.	1
With his knowledge of the Islands, their recent origin and their isolation from the mainland, he concluded that all the species of finches that were present on the islands	1
probably originated from a common ancestor. He also noted that each adapted in some way to some habitat or niche of	1
the environment and from island to island. Isolation of the Galapagos flock from the mainland was an	1
important aspect of their developing into a new species.	1
Possible:	6
Maximum:	5

Teacher Notes

DRAFT

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 05
UNIT NAME: THEORY OF EVOLUTION

TOPIC: Speciation
CURRICULAR EMPHASIS: Nature of Science

INSTRUMENT CODE: B051KdER.02
GUIDELINE OBJECTIVE CODE: 51Kd
INSTRUMENT TYPE: ER
KLOPFER: A.1, A.2, A.3, A.5, I.3
DIFFICULTY LEVEL: M
TIME ALLOCATION:

KEYWORDS: Galapagos Islands Darwin

Guideline Objective

Students will be expected to, including reference to Erasmus Darwin, Malthus, Lyell and the voyage of the HMS *Beagle*, describe briefly how Charles Darwin gathered evidence and developed his ideas.

Item Focus

The student should be able to describe how Darwin's observations on the Galapagos Islands contributed to the development of his ideas.

Item

After recounting his many observations of the forms of life he found on the Galapagos Islands, Charles Darwin expressed wonder at the particular distribution of species:

'Why, on these small points of land, which within a late geological period must have been covered by the ocean, which are formed of basaltic lava, and therefore differ in geological character from the American continent, and which are placed under a peculiar climate, —why were their aboriginal inhabitants... created on American types of organization?'

The Voyage of the Beagle, 1860.

Although the "vast majority of all the land animals, and more than half of the flowering plants" appeared to be new species, different from those on the mainland of South America, yet they resembled the mainland species more than the species on other Pacific islands. Since the Galapagos Islands are separated from the mainland by 1000 km of open ocean, how could these similarities and differences have arisen?

Response/Marking Scheme

The ancestors of the Galapagos species must have reached the islands from the mainland. 1

Birds could travel such distances with the help of strong winds, but it would have happened only infrequently that they would have reached such a small target. 1

Aquatic animals could have come by swimming. 1

Land animals may have travelled in rafts of vegetation that are often seen floating in the ocean after a storm. 1

Plant seeds might have been transported within the digestive tract of birds, or in a floating raft. 1

Once the pioneers had arrived, they were small populations 1

with restricted gene pools. 1

The islands are far enough apart that each would have had its own gene pool, with little mixing from other pools. 1

Mutations would have spread more quickly than in the larger gene pools of the mainland; changing the gene pools, and 1

creating new species. 1

Possible: 10

Maximum: 7

Teacher Notes

DRAFT

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B051KeMC.02
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: Part 1(3.2-8)(3.3a) 51Ke
UNIT NUMBER: 05	INSTRUMENT TYPE: MC
UNIT NAME: THEORY OF EVOLUTION	KLOPFER: A.1, A.2, A.3, A.9, I.1, I.3
TOPIC: Scientific Theories	DIFFICULTY LEVEL: M
CURRICULAR EMPHASIS: Nature of Science	TIME ALLOCATION:

KEYWORDS: theory

Guideline Objective

The student will become scientifically literate, distinguishing among scientific concepts, principles and theories.

Item Focus

The student will indicate the unique nature of the theory of evolution in biology.

Item

Theories of evolution apply to biology; they do not apply to physics and chemistry. One reason for this is that the

☐ A. manner in which chemical and physical reactions take place is influenced by the history of the reacting entities.

☐ B. histories of reacting particles affect their structure.

☐ C. history of organisms has affected their structure and function.

☐ D. particles at the atomic and molecular levels have reacted differently in the past than they react in the present.

☐ E. organisms have not changed over long periods of time.

Response/Marking Scheme

Correct response: C

Teacher Notes

DRAFT

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 05
UNIT NAME: THEORY OF EVOLUTION

TOPIC: Scientific Theories
CURRICULAR EMPHASIS: Nature of Science

INSTRUMENT CODE: B051KeMC.03
GUIDELINE OBJECTIVE CODE: Part 1(3.2-8),(3.3-a) 51Ke
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3, A.9, I.1
DIFFICULTY LEVEL: M
TIME ALLOCATION:

KEYWORDS: Darwin theory.

Guideline Objective

The student will become scientifically literate, distinguishing among scientific concepts, principles and theories.

Item Focus

The student will identify the reason the Darwinian concept is referred to as a scientific theory.

Item

The evolutionary ideas proposed by Darwin are referred to as a scientific theory because

☐ A. the ideas are used to explain both the diversity and unity displayed by living things.

☐ B. the ideas concerning diversity and unity of life forms do not have sufficient evidence to be called facts.

☐ C. there is no way of establishing the validity of the ideas concerning the unity and diversity of life forms.

☐ D. the ideas do not agree with accepted scientific concepts.

☐ E. all ideas in science are called theories.

Response/Marking Scheme

Correct response: A

Teacher Notes

DRAFT

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B051KeEE.01
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 51Ke
UNIT NUMBER: 05	INSTRUMENT TYPE: EE
UNIT NAME: THEORY OF EVOLUTION	KLOPFER: A.1, A.2, A.3, A.9, I.1
	DIFFICULTY LEVEL: H
TOPIC: Scientific Theories	TIME ALLOCATION:
CURRICULAR EMPHASIS: Nature of Science	

KEYWORDS: biological evolution theory

Guideline Objective

Students will be expected to, using the theory of natural selection as an example, differentiate among empirical facts, a hypothesis, and a theory and describe the origin, purpose, and development of scientific theories, giving examples of their usefulness and limitations.

Item Focus

The students will explain how the theory of natural selection satisfies the criteria of a scientific theory, and hence is a scientific theory.

Item

Justify the modern concept of biological evolution as being considered as a scientific theory. In your answer,

A. develop a list of 4 characteristics of scientific theories.

B. use examples from the modern theory of evolution to support your argument that it is a scientific theory.

Response/Marking Scheme

A. Scientific theories have a number of important characteristics including the following:

1. Theories explain naturally occurring phenomena 1
   in terms of a number of coherent statements which are interconnected, 1
   and adhere to basic beliefs of science (such as uniformitarianism). 1
2. Theories use "postulated entities", that is things that are postulated to exist, 1
   but for which there is only indirect or highly circumstantial evidence. 1
3. Theories guide researchers in terms of what information will be construed as data and evidence. 1
4. Theories suggest possible lines of investigation. 1
5. Theories have deductive consequences that are theoretically amenable to empirical verification. 2
6. Theories relate intimately to a metaphor which is often referred to as a scientific model, used to suggest further lines of inquiry. 2

B. The concepts of modern evolutionary theory consist of a number of statements, both inductive and deductive, 2

linked together in a coherent pattern through devices such as cause and effect. 2

For example, genetic variation can be caused by mutations and genetic crossing-over and recombination. The concept of mutations can be explained in terms of disruptions in nitrogenous base sequences within DNA. Crossing-over events can be observed using the microscope. Empirically, the statistical rate of mutations can be ascertained. 2

Modern evolutionary theory contains a number of postulated entities such as gene pools and genetic drift. Although these concepts are postulated, the notions can be used to deduce possible consequences, such as extinction of species in the past. 2

Modern evolutionary theory has outlined a research programme. For example, assuming evolution to be the case, one can order fossils in an evolutionary pattern, order organisms according to their biochemical similarities, and order them according to similarities of structure (comparative morphology and anatomy). 2

The acceptance of the concepts of biological evolution leads to deductive consequences. For example, the changing of environmental factors would lead

to new environmental niches which could be filled with organisms possessing particular adaptations. These adaptations could be deduced knowing the characteristics of the new niches. 2

The metaphor of natural selection is based on the previous metaphor of artificial selection. This metaphor suggested a line of investigation involving the inducing of variations within a species (e.g. UV radiation of bacteria) and the selection of variants that can survive specified stringent conditions (lack of specific nutrients). 2

Possible: 25

Maximum: 20

Quality: 2

Total: 22

Teacher Notes

DRAFT

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B051KeER.02
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 51Ke
UNIT NUMBER: 05	INSTRUMENT TYPE: ER
UNIT NAME: THEORY OF EVOLUTION	KLOPFER: A.1, A.2, A.6
	DIFFICULTY LEVEL: H
TOPIC: Scientific Theories	TIME ALLOCATION:
CURRICULAR EMPHASIS: Nature of Science	

KEYWORDS: natural selection theory

Guideline Objective

Students will be expected to, using the theory of natural selection as an example, differentiate among empirical facts, a hypothesis, and a theory, and describe the origin, purpose, and development of scientific theories.

Item Focus

The student should be able to state Darwin's theory of natural selection and explain the purpose of scientific theories in general.

Item

Charles Darwin not only proposed a theory of organic evolution, he went a giant step further by suggesting a possible mechanism, the theory of natural selection.

A. State Darwin's theory of natural selection and describe the factual observations which led Darwin to propose it.

B. Describe the purpose of scientific theories and explain how they usually originate and develop.

Response/Marking Scheme

A. Organisms best suited to their environment would have a selective advantage to live longer and produce 1

more offspring with similar selective advantages. 1

The next generation might be more likely to inherit 1

these adaptations than those organisms without the selective advantages. 1

Factual Observations:

Variation exists within a species. 1

Although there is an unlimited potential for reproduction, the numbers of natural populations remain fairly constant. 2

B. Purpose:

The purpose of a theory is to provide possible explanations of observed, factual evidence. 1

Origin:

Theories generally originate from 'ideas' or hypotheses which are possible explanations of observed phenomena. 1

Development:

Scientific theories, by their very nature, are constantly being tested and evaluated. 1

When a hypothesis is supported by many lines of evidence from different sources it is accepted as a theory. 1

As new technology leads to additional knowledge, theories are modified. 1

The 'new' theory is then tested experimentally to find whether it confirms predicted results or not 1

or whether it does not confirm predicted results, which would lead to further modification and testing. 1

Possible: 14

Maximum: 10

Quality: 2

Total: 12

Teacher Notes

DRAFT

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B051KeER.03
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 51Ke
UNIT NUMBER: 05	INSTRUMENT TYPE: ER
UNIT NAME: THEORY OF EVOLUTION	KLOPFER: A.1, A.2, A.3, A.9
	DIFFICULTY LEVEL: M
TOPIC: Scientific Theories	TIME ALLOCATION:
CURRICULAR EMPHASIS: Nature of Science	

KEYWORDS: theory

Guideline Objective

Students will be expected to, using the theory of natural selection as an example, differentiate among empirical facts, a hypothesis, and a theory, and describe the origin, purpose, and development of scientific theories.

Item Focus

The student should be able to identify the purpose of a scientific theory.

Item

A. What is the purpose of a scientific theory?

B. Illustrate your answer by showing how the theory of natural selection serves its purpose.

Response/Marking Scheme

A. A theory is an explanation	1
based on observations,	1
involving logical reasoning.	1
Its secondary purpose is to allow prediction of new discoveries	1
B. The theory of natural selection was proposed by Darwin and Wallace to	
explain the diversity of	1
and the similarities among organisms,	1
using a logical mechanism (selection by natural forces)	1
to account for change.	
It has been very fruitful in predicting new fields of biological study.	1

Possible: 8

Maximum: 5

Teacher Notes

DRAFT

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 05
UNIT NAME: THEORY OF EVOLUTION

TOPIC: Darwin's Theory
CURRICULAR EMPHASIS: Nature of Science

INSTRUMENT CODE: B051KfMC.01
GUIDELINE OBJECTIVE CODE: 51Kf
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3, A.8, I.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: natural selection variability

Guideline Objective

Students will be expected to explain why Darwin was unable to account for the mechanism of inheritance of traits in his theory.

Item Focus

The student should be able to identify the concept that was missing from Darwin's explanation of evolution.

Item

Which of the following was <u>**NOT**</u> explained by Darwin's theory of natural selection?

☐ A. adaptation

☐ B. fossils

☐ C. source of variability in species

☐ D. geographical distribution of related groups.

☐ E. changes in domesticated animals.

Response/Marking Scheme

Correct response: C

Teacher Notes

DRAFT

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 05
UNIT NAME: THEORY OF EVOLUTION

TOPIC: Neo-Darwinian Theory
CURRICULAR EMPHASIS: Nature of Science

INSTRUMENT CODE: B051KfMC.02
GUIDELINE OBJECTIVE CODE: 51Kf
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3, A.9.
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: comparative biochemistry gene theory

Guideline Objective

Students will be expected to explain why Darwin was unable to account for the mechanism of inheritance of traits in his theory.

Item Focus

The student should be able to identify differences between Darwin's theory of Descent with Modification and the modern theory of evolution.

Item

Which of the following are part of the theory of evolution today, but were not part of the theory of descent with modification presented by Charles Darwin?

☐ A. The record of fossil life through past ages.

☐ B. The effects of selective breeding in changing domestic animals and cultivated plants.

☐ C. Comparative biochemistry and the gene theory.

☐ D. The effects of isolation on island populations.

☐ E. Comparative studies of anatomy and embryology.

Response/Marking Scheme

Correct response: C

Teacher Notes

DRAFT

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 05
UNIT NAME: THEORY OF EVOLUTION

TOPIC: Natural Selection
CURRICULAR EMPHASIS: Nature of Science

INSTRUMENT CODE: B051KfMC.03
GUIDELINE OBJECTIVE CODE: 51Kf
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.3, A.5, A.9, I.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: Darwin

Guideline Objective

Item Focus

The student should be able to identify the facts established by Darwin that support the theory of natural selection.

Item

What very valuable clue to the mechanisms of adaptation and speciation was not available for Charles Darwin to use in formulating his theory?

- [ ] A. artifical breeding of domestic animals and plants.
- [ ] B. the species of Galapagos finches.
- [ ] C. Sir Charles Lyell's book "Principles of Geology".
- [ ] D. South American fossils.
- [ ] E. Gregor Mendel's work on genetics.

Response/Marking Scheme

Correct response: E

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 05
UNIT NAME: THEORY OF EVOLUTION

TOPIC: Theory of Inheritance
CURRICULAR EMPHASIS: Nature of Science

INSTRUMENT CODE: B051KfEE.01
GUIDELINE OBJECTIVE CODE: 51Kf
INSTRUMENT TYPE: EE
KLOPFER: A.1, A.2, A.3, A.5, A.9
DIFFICULTY LEVEL: H
TIME ALLOCATION:

KEYWORDS: heredity Darwin Weismann Mendel

Guideline Objective

Students will be expected to explain why Darwin was unable to account for the mechanism of inheritance of traits in his theory.

Item Focus

The student should be able to explain the historical development of the explanation for the mechanisms of heredity.

Item

"Oh, he looks just like his father" is an expression people often use when they see offspring for the first time.

This common observation has been made for generations, however, the explanation for such similarity was not given much thought until the time of Mendel and Darwin. Darwin was unable to account for the mechanism of inheritance of traits. Even Mendel's work has been altered in the light of knowledge of the structure and function of DNA. Describe the contributions to the theory of mechanisms of inheritance of Darwin, Weismann, Mendel and the modern biochemical view of genes, variation and mutation.

Response/Marking Scheme

Darwin	
There must be some physical connection between parent and	1
child which had to be transmitted through the gametes.	1
Weismann	
There is a physical continuity between parent and offspring	1
which is the result of the transmission of germ plasm through the gonads.	1
The physical being was a result of germ plasm, and since the gonads consisted of germ plasm, the germ plasm was the	1
hereditary message.	1
The hereditary information is unaffected by the phenotype.	1
The germ plasm unites the individuals of a species. Natural selection perserves or eliminates variation in the germ plasm.	1
Mendel	
Mendel's theory of inheritance is very similar to that of Weismann. The germ plasm referred to by Weismann are discrete units that Mendel called "factors"	1
Each organism has a pair of factors which control the appearance of a trait.	1
These factors are transmitted as unchanging units.	1
When the reproductive cells develop, the factors separate and are distributed as units to each gamete	1
If an organism has two unlike factors for a given characteristic, one may be expressed to the total exclusion of the other.	1
Modern Theory	
Mendel's laws still apply to many situations.	1
Mendel's factors are replaced by the concept of allele	1
which is an alternative form of a gene. Genes are a part of a discrete segregating unit called a chromosome.	2
This explains variation in hereditary patterns such as linkage.	1
Genes and chromosomes are composed of DNA and DNA	1
functions in replication and transcription.	1
Hereditary information, passed from one generation to another, is instrumental in formulating the phenotype.	1
Variations arise through mutation of the DNA. Nature influences the frequency of these variations through natural selection and hence lead to evolutionary trends.	1
Possible:	22

Maximum: 13

Quality: 2

Total: 15

Teacher Notes

DRAFT

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 05
UNIT NAME: THEORY OF EVOLUTION

TOPIC: Neo-Darwinian Theory
CURRICULAR EMPHASIS: Nature of Science

INSTRUMENT CODE: B051KfER.01
GUIDELINE OBJECTIVE CODE: 51Kf
INSTRUMENT TYPE: ER
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: M
TIME ALLOCATION:

KEYWORDS: Mendel

Guideline Objective

Students will be expected to explain why Darwin was unable to account for the mechanism of inheritance of traits in his theory.

Item Focus

Same as above.

Item

A. At the time of Darwin, what ideas prevailed about the mechanism of heredity?

B. How did Gregor Mendel's work influence these ideas?

Response/Marking Scheme

A. At Darwin's time, the major "theory" of inheritence (pangenesis) postulated that 1

traits were drawn from all parts 1

of the father's body and incorporated into a small human 1

being (homunculus) that could be seen curled up inside each sperm cell. With such a belief, the inheritence of acquired characteristics was a logical consequence. 1

Darwin stated that "like produces like" with respect to individual variations, and that variations are more 1

often transmitted from a male parent to male offspring. 1

Darwin felt that environmental influence was more important than heredity in causing variability. 1

B. Mendel aided the understanding of the mechanism of heredity. 1

Mendel's discovery of dominant and recessive alleles 2

led to an understanding of the random assortment 1

that leads to new gene combinations upon which natural selection operates. 1

Possible: 12

Maximum: 6

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 05
UNIT NAME: THEORY OF EVOLUTION

TOPIC: Darwin's theory
CURRICULAR EMPHASIS: Nature of Science

INSTRUMENT CODE: B051KfSA.01
GUIDELINE OBJECTIVE CODE: 51Kf
INSTRUMENT TYPE: SA
KLOPFER: A.1, A.3, A.5, I.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: genes inheritance

Guideline Objective

Students will be expected to explain why Darwin was unable to account for the mechanism of inheritance of traits in his theory.

Item Focus

The student should be able to state the main concept lacking from the Darwin/Wallace theory of natural selection.

Item

What was the most important lack of information in Darwin's lifetime for the completion of his theories?

Response/Marking Scheme

The mechanism of genetic inheritance, or knowledge of genes and chromosomes.

Possible: 2

Maximum: 2

Teacher Notes

DRAFT

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 05
UNIT NAME: THEORY OF EVOLUTION

TOPIC: Species Concept
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B051KgMC.01
GUIDELINE OBJECTIVE CODE: 51Kg
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: species

Guideline Objective

Students will be expected to explain both the morphological and biological concept of a species, and explain why it is difficult to give a rigorous definition of a species that fits all occasions.

Item Focus

The student should be able to identify the singular of the word, "species".

Item

As an educated biologist, you want to use singular and plural terms correctly. You probably know the pair of terms, genus/genera. But what is the singular of *species*?

☐ A. specie

☐ B. specium

☐ C. speci

☐ D. specia

☐ E. species

Response/Marking Scheme

Correct response: E

Teacher Notes

DRAFT

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B051KgMC.03
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 51Kg
UNIT NUMBER: 05	INSTRUMENT TYPE: MC
UNIT NAME: THEORY OF EVOLUTION	KLOPFER: A.1, A.2, A.3
	DIFFICULTY LEVEL: L
TOPIC: Species Concept	TIME ALLOCATION:
CURRICULAR EMPHASIS: Solid Foundations	

KEYWORDS: species

Guideline Objective

Students will be expected to explain both the morphological and biological concept of a species, and explain why it is difficult to give a rigorous definition of a species that fits all occasions.

Item Focus

The student should be able to identify the key characteristic of a species.

Item

In nature, individuals of different species

☐ A. are unable to interbreed to produce viable offspring.

☐ B. must interbreed occasionally.

☐ C. interbreed preferentially with one another.

☐ D. do not normally interbreed with one another.

☐ E. successfully interbreed in captivity.

Response/Marking Scheme

Correct response: D

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B051KgMC.04
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 51Kg
UNIT NUMBER: 05	INSTRUMENT TYPE: MC
UNIT NAME: THEORY OF EVOLUTION	KLOPFER: A.1, A.2, A.3
	DIFFICULTY LEVEL: L
TOPIC: Species Concept	TIME ALLOCATION:
CURRICULAR EMPHASIS: Solid Foundations	

KEYWORDS: species

Guideline Objective

Students will be expected to explain both the morphological and biological concept of a species, and explain why it is difficult to give a rigorous definition of a species that fits all occasions.

Item Focus

The student should be able to identify the major criterion of the species concept.

Item

The idea that all humans now living belong to the same species is best supported by the fact that they all

☐ A. organize themselves into groups sharing a common culture.

☐ B. have become adapted for living everywhere in the world.

☐ C. have developed language enabling them to communicate with others in their group.

☐ D. are capable of interbreeding to produce fertile offspring.

☐ E. are genetically identical.

Response/Marking Scheme

Correct response: D

Teacher Notes

DRAFT

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 05
UNIT NAME: THEORY OF EVOLUTION

TOPIC: Species Concept
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B051KgMC.05
GUIDELINE OBJECTIVE CODE: 51Kg
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: genus species

Guideline Objective

Students will be expected to explain both the morphological and biological concept of a species, and explain why it is difficult to give a rigorous definition of a species that fits all occasions.

Item Focus

The student should be able to identify the relationship between two animals that interbreed to produce sterile offspring.

Item

If two kinds of animals are able to interbreed, but always produce sterile offspring, they are most likely of the same

☐ A. genus and species.

☐ B. genus, but of different species.

☐ C. species, but of different genera.

☐ D. family.

☐ E. species, but of different variety (subspecies).

Response/Marking Scheme

Correct response: B

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 05
UNIT NAME: THEORY OF EVOLUTION

TOPIC: Species Concept
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B051KgMC.06
GUIDELINE OBJECTIVE CODE: 51Kg
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3, A.9, I.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: species

Guideline Objective

Students will be expected to explain both the morphological and biological concept of a species, and explain why it is difficult to give a rigorous definition of a species that fits all occasions.

Item Focus

The student should be able to identify a definition of species that is compatible with the modern theory of evolution.

Item

According to the modern theory of evolution, the best definition of a species is

☐ A. a group of organisms having common structural characteristics distinct from those of other groups.

☐ B. a natural population of organisms with the same ancestry that is reproductively isolated from all other populations.

☐ C. one of a limited number of universal types of organisms, recognizable by their essential morphology.

☐ D. a mental concept invented to describe a great number of individuals, but having no actual existence in nature.

☐ E. a genetic unit consisting of an interconnecting gene pool.

Response/Marking Scheme

Correct response: B

Teacher Notes

DRAFT

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 05
UNIT NAME: THEORY OF EVOLUTION

TOPIC: Species Concept
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B051KgER.01R
GUIDELINE OBJECTIVE CODE: 51Kg
INSTRUMENT TYPE: ER
KLOPFER: A.1, A.2, A.3.
DIFFICULTY LEVEL: H
TIME ALLOCATION:

KEYWORDS: species race

Guideline Objective

Students will be expected to explain both the morphological and biological concept of a species, and explain why it is difficult to give a rigorous definition of a species that fits all occasions.

Item Focus

Same as above.

Item

A. Define species.

B. Discuss the meaning of species in terms of

1. different races of human beings;

2. the following possible ancestors of humans:
Homo erectus, *Homo sapiens neanderthalensis*, and *Homo habilis*.

Response/Marking Scheme

A. A species is a population of similar individuals 2
of similar ancestry, and the potential to interbreed 2
naturally among the population, but not with other populations, to produce viable offspring. 3

B.

1. All human races are members of the same species 2
and sub-species, *Homo sapiens sapiens*, because 2
members of any race are capable of producing viable offspring with any other race. 1

2. Fossil species cannot be observed producing viable offspring, and are therefore distinguished on structural features. 2

When enough structural features characterize a fossil population, it is given a species name. 1

*Homo habilis*is thought to have been the ancestor 1
of *H. erectus*, which in turn may have given rise to 1
H. sapiens.

*H. s. neanderthalensis*is a distinguishable population of early humans. 1

Neanderthals may have been capable of interbreeding with the younger subspecies, *H. s. sapiens*, which may 1
have assimilated them or displaced them. 1

Possible: 20

Maximum: 14

Teacher Notes

DRAFT

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 05
UNIT NAME: THEORY OF EVOLUTION

TOPIC: Species Concept
CURRICULAR EMPHASIS: Nature of Science

INSTRUMENT CODE: B051KgER.02R
GUIDELINE OBJECTIVE CODE: 51Kg
INSTRUMENT TYPE: ER
KLOPFER: A.1, A.2, A.3, A.6
DIFFICULTY LEVEL: H
TIME ALLOCATION:

KEYWORDS: species

Guideline Objective

Students will be expected to explain both the morphological and biological concept of a species, and explain why it is difficult to give a rigorous definition of a species that fits all occasions.

Item Focus

Same as above.

Item

A. Why is it impossible to give a rigorous definition of a species that fits all occasions?

B. Which of the three following definitions of a species would a biologist consider the most satisfactory? Give reasons, with specific examples where possible. State reasons for rejecting the other two.

   I. A species is a group of organisms with a high degree of structural similarity.

   II. A species is that stage of the evolutionary process at which the once actually or potentially interbreeding array of forms become segregated into two or more separate arrays that are physiologically incapable of breeding.

   III. A species is a group of similar organisms that can interbreed, under natural conditions, to produce fertile, living offspring.

Response/Marking Scheme

A. The infinite diversity of living organisms makes it impossible to fit all living organisms into clearly defined groups. 1

There will always be some organisms which do not fall within the most comprehensive of definitions. 1

Note to teacher: If student selects a different option, and suitably defends it, allow equal marks.

B. Definition III. is most satisfactory. 1

It includes both morphological and biological concepts 1

and excludes some groups which would prove to be exceptions. 1

'Under natural conditions' covers the animals which never breed in the wild, but have bred in captivity, 1

e.g. lion and tiger. 1

It also excludes those animals that may be physiologically capable of breeding, but for a variety of reasons (geographic, behavioural, territorial) never meet to breed in the wild. 1

e.g. arctic blue whales/antarctic blue whales. 1

'Fertile offspring' covers animals that breed successfully, however, their offspring are sterile, 1

e.g. horse and donkey, producing a mule. 1

'Living offspring' covers animals that breed, and where the embryo stages survive but never reach adultood, 1

e.g. several species of frog. 1

Definition I. rejected- because it deals solely with the morphological concept of a species, ignoring the biological concept. 1

Any comprehensive definition must include the ability to interbreed 1

Many groups of animals with structural similarities are incapable of interbreeding, mostly because they are genetically incompatible 1

e.g. the group of flies who mimic the structure of a wasp, structurally very similar, but genetically very different. 1

Definition II. rejected- because it suggests that genetic incompatibility is the only criterion that prevents interspecific breeding 1

many other factors prevent interbreeding, e.g. habitat difference, the two groups simply never encounter one another; 1

temporal differences in breeding times; 1

mechanical differences; 1

courtship behaviour, especially in birds; 1

natural geographic barriers. 1

Possible: 23

Maximum: 15

Quality: 2

Total: 17

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 05
UNIT NAME: THEORY OF EVOLUTION

TOPIC: Species Concept
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B051KgER.03
GUIDELINE OBJECTIVE CODE: 51Kg
INSTRUMENT TYPE: ER
KLOPFER: A.1, A.2, A.3, A.6
DIFFICULTY LEVEL: H
TIME ALLOCATION:

KEYWORDS: species

Guideline Objective

Students will be expected to explain both the morphological and biological concept of a species, and explain why it is difficult to give a rigorous definition of a species that fits all occasions.

Item Focus

The student should be able to explain the morphological and biological concept of a species.

Item

A. Distinguish between the morphological and biological concept of a species.

B. State two advantages and two disadvantages for each of the concepts.

Response/Marking Scheme

A.

The morphological concept of a species is based on observable, structural or anatomical similarities and differences between organisms. 1

Should two organisms be sufficiently different in 1

structure then they are determined to be different in species. 1

If two organisms were markedly similar in structure, they would be considered the same species. 1

The biological concept of a species is based on the ability of members of a population to interbreed and produce fertile offspring. 1

This concept emphasises reproductive, hence genetic isolation as the most significant factor in determining members of a species. 1

Members of a species are capable of sharing the same gene pool. 1

B. Morphological Concept

Advantages-

Fossils are classified on the basis of morphology. 1

The concept is convenient and practical to use. 1

It develops clear, precise descriptions of species which are universally available and understood by others. 1

Specimens of different species may be preserved for reference. 1

Disadvantages-

There are structural differences in some organisms at different stages of their life history (e.g. egg-larva-pupa of an insect), 1

The concept implies that the individual is the basic unit 1

of a species. Many organisms are structurally very similar but biologically very different (as a result of convergent evolution) and incompatible, 1

Variations within a species make it difficult to determine the degree of difference. 1

Biological Concept

Advantages-

The criterion of reproductive isolation is relatively simple to apply, and relatively unambiguous. 2

Therefore organisms can be classified readily into species. 1

Disadvantages-

This concept does not apply to organisms that only reproduce asexually. 1

It cannot be applied to fossils. 1

In some cases, although interbreeding has never been observed in the wild, two organisms have bred successfully in captivity (e.g. lion and tiger). 1

Although two populations may be physiologically capable of interbreeding (and thus the same biological species) geographic isolation may prevent this (e.g. blue whales of arctic waters and antarctic waters). 1

Possible: 23

Maximum: 12

Quality: 2

Total: 14

Teacher Notes

DRAFT

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 05
UNIT NAME: THEORY OF EVOLUTION

TOPIC: Species Concept
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B051KgSA.01
GUIDELINE OBJECTIVE CODE: 51Kg
INSTRUMENT TYPE: SA
KLOPFER: A.1, A.2, A.3, A.10, A.11, C.1
DIFFICULTY LEVEL: M
TIME ALLOCATION:

KEYWORDS: species

Guideline Objective

Students will be expected to explain both the morphological and biological concept of a species, and explain why it is difficult to give a rigorous definition of a species that fits all occasions.

Item Focus

The student should be able to define species and discuss variability within a species.

Item

A. Define species.

B. Explain how a chihuahua and a St. Bernard can actually be members of the same species, even though they cannot naturally breed.

Response/Marking Scheme

A. A species is defined as a population of organisms — 1
that are similar in appearance, of common ancestry — 2
and are capable of interbreeding naturally with one — 1
another to produce viable offspring. — 1

B. If this definition were taken literally, then the two dogs would not be considered members of the same species. — 1

This inability to breed is based on physical incompatabilities. Although they cannot actually breed one with the other, through a chain of matings with progressively larger (or smaller) dogs, they actually contribute to and share genes from the same gene pool. — 1

Since they share genetic information, they are recognized as members of the same species. — 1

Possible: 8

Maximum: 6

Teacher Notes

DRAFT

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B051KgSA.02
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 51Kg
UNIT NUMBER: 05	INSTRUMENT TYPE: SA
UNIT NAME: THEORY OF EVOLUTION	KLOPFER: A.1, A.2, A.3, A.10, A.11, C.1
	DIFFICULTY LEVEL: L
TOPIC: Species Concept	TIME ALLOCATION:
CURRICULAR EMPHASIS: Solid Foundations	

KEYWORDS: species

Guideline Objective

Students will be expected to explain both the morphological and biological concept of a species, and explain why it is difficult to give a rigorous definition of a species that fits all occasions.

Item Focus

The student should be able to discuss a suitable definition of species.

Item

Comment on the following definition:

A species is comprised of similar organisms that are capable of interbreeding.

Response/Marking Scheme

The two factors expressed by the above definition are both requirements in determining whether two organisms are members of the same species.	1
The definition stops short, since it is critical that the organisms not only mate, but are capable of producing viable offspring.	2
Without the assurance of the transmission of the genetic information, the organisms cannot be defined as members of the same species.	1
Possible:	4
Maximum:	4

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B051KhER.01
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 51Kh
UNIT NUMBER: 05	INSTRUMENT TYPE: ER
UNIT NAME: THEORY OF EVOLUTION	KLOPFER: A.1, A.2, A.3, A.5, A.9
	DIFFICULTY LEVEL: M
TOPIC: Populations	TIME ALLOCATION:
CURRICULAR EMPHASIS: Solid Foundations	

KEYWORDS: gene frequencies gene pool mutation

Guideline Objective

Students will be expected to explain with reference to the gene pool of a population why the theory of biological evolution applies to populations of organisms and not to individuals.

Item Focus

Same as above.

Item

"Individuals do not evolve; populations evolve".

In relationship to gene frequencies in a gene pool, explain this statement.

Response/Marking Scheme

Evolution involves a change in allele frequencies within	1
the gene pool of an interbreeding population, not an	1
individual change in one individual of that population.	1
The frequency of one allele changes at the expense of another.	1
Changes in alleles are the result of a random mutation of	1
an existing gene, changes in the DNA structure. This	1
occurs initially in one individual.	1
Over time, reproductive success of the individual may	1
result in an increase of the mutant allele within the gene pool.	1
These changes in frequency are the result of random chance or natural selection.	2
If the change is beneficial or deleterious to the survival of the organism within the environmental constraints or if the environment changes and therefore, the survival value of the gene changes, the gene frequency will change.	2
Evolution, therefore, is replacement of the old allele by the new form within the gene pool.	2
Possible:	15
Maximum:	12

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 05
UNIT NAME: THEORY OF EVOLUTION

TOPIC: Modern Theory
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B051KhER.02
GUIDELINE OBJECTIVE CODE: 51Kh
INSTRUMENT TYPE: ER
KLOPFER: A.1, A.2, A.3, A.5, A.8.
DIFFICULTY LEVEL: M
TIME ALLOCATION:

KEYWORDS: competition graphical analysis

Guideline Objective

Students will be expected to explain with reference to the gene pool of a population why the theory of biological evolution applies to populations of organisms and not to individuals.

Item Focus

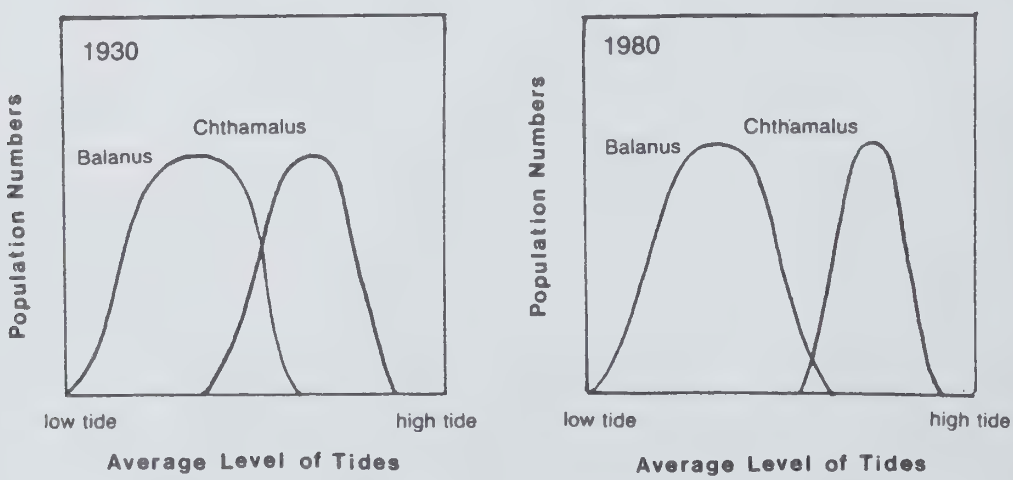
The student should be able to explain how competition between species can act as a selection agent to change a population.

Item

*Balanus*and *Chthamalus*are two species of barnacles that live on rocks between the tides. They compete for the same space and food. Figure 5K.12 represents the populations of the two species over a long period of time.

Predict the evolutionary consequences of the competition between the two species over evolutionary time.

DISTRIBUTION OF TWO SPECIES OF BARNACLES



Response/Marking Scheme

The graph shows that the area of overlap between the two species is decreasing. 1
Balanus has maintained its distribution over its range, while *Chthamalus* is narrowing its range. 2

Prediction: narrowing its range will make *Chthamalus* very vulnerable to changes in the environment, and its position with respect to the high tide will leave it exposed more than *Balanus.* Thus we predict that it may eventually become extinct while *Balanus* will continue to thrive. 2

Possible: 5

Maximum: 5

Teacher Notes

Research shows that *Balanus* is a more aggressive competitor, growing faster, smothering and crushing *Chthamalus.* Competition also reduced the reproductive efficiency of *Chthamalus.* Competition determines the distribution of species at the lower intertidal limit; while physical factors such as temperature and availability of water determine the upper limit.

Connell, J.H. "The Influence of Interspecific Competition and other Factors on the Distribution of the barnacle, *Chthamalus stellatus.*" in *Ecology*, Vol. 42, No. 4, 1961.

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B051KhER.03
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 51Kh
UNIT NUMBER: 05	INSTRUMENT TYPE: ER
UNIT NAME: THEORY OF EVOLUTION	KLOPFER: A.1, A.5, A.9
	DIFFICULTY LEVEL: H
TOPIC: Modern Theory	TIME ALLOCATION:
CURRICULAR EMPHASIS: Solid Foundations	

KEYWORDS: variation

Guideline Objective

Students will be expected to explain with reference to the gene pool of a population why the theory of biological evolution applies to populations of organisms and not to individuals.

Item Focus

The student should be able to use the modern theory of evolution to explain change in a population in response to selection pressure.

Item

Using a bell curve, explain how a population of short-necked ancestors of the giraffe is thought to have evolved into the present population of long-necked forms as low-growing vegetation became scarce.

Response/Marking Scheme

Diagram: bell curve, labelled to represent variation in neck length of ancestral population.	2
Diagram of a bell curve, labelled to represent variation in neck length of present population, with shift in mean neck length from first bell curve.	2
In any population, there is a wide variation in any trait.	1
This variation may be due to random mutation.	1
With low-growing vegetation, all individuals would have equal opportunity to survive and leave offspring, regardless of neck length.	2
When low growing vegetation became scarce, perhaps due to a change in climate — drier — many shrubs and herbs died — increased selection pressure on giraffe population.	2
Longer-necked members of the population had more opportunity to eat higher leaves, consequently achieving better states	1
of nutrition and therefore, better success in reproduction.	2
Many of their offspring would have alleles for longer necks.	1
Over many generations, there would be a gradual shift in the curve of neck lengths.	1
Possible:	15
Maximum:	10

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B051KhER.04
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 51Kh
UNIT NUMBER: 05	INSTRUMENT TYPE: ER
UNIT NAME: THEORY OF EVOLUTION	KLOPFER: A.1, A.2, A.3, A.10, C.1, C.2, E.2
TOPIC: The Modern Theory	DIFFICULTY LEVEL: M
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:

KEYWORDS: natural selection gene pool

Guideline Objective

Students will be expected to explain with reference to the gene pool of a population why the theory of biological evolution applies to populations of organisms and not to individuals.

Item Focus

The student should be able to explain why some animals do not appear to have changed over very long periods of time.

Item

If evolution is truly a force of nature, shaping new organisms, why is it that certain species and groups, such as the sharks, have remained apparently unchanged for millions of years?

Response/Marking Scheme

Once an organism has evolved a form and functions that adapt it for survival in a particular environment, then	1
there is no selection pressure for further change,	1
unless the environment also changes.	1
Mutations that reduce efficiency in functioning are selected against.	1
Neutral mutations may have occurred, but since these are not visible in the phenotypes of the shark population, we can only assume they are in the gene pool.	1
The Hardy-Weinberg principle shows that a particular gene pool will remain stable unless there are forces for change.	1
Possible:	6
Maximum:	5

Teacher Notes

DRAFT

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B051KhER.05
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 51Kh
UNIT NUMBER: 05	INSTRUMENT TYPE: ER
UNIT NAME: THEORY OF EVOLUTION	KLOPFER: A.1, A.2, A.3, A.10, C.1, C.2, E.2
TOPIC: The Modern Theory	DIFFICULTY LEVEL: M
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:

KEYWORDS: Hardy-Weinberg law

Guideline Objective

Students will be expected to explain with reference to the gene pool of a population why the theory of biological evolution applies to populations of organisms and not to individuals.

Item Focus

The student should be able to explain how natural selection might begin to cause changes after a very long period of stability.

Item

Under what conditions would a species, which had remained apparently unchanged for a million years, begin to change physiologically in a relatively short time? Use the Hardy-Weinberg principle in your explanation.

Response/Marking Scheme

To have remained unchanged, the species must have attained a form and function well adapted to its environment.	1
For change to begin, it is likely that the environment had begun to change,	1
and was selecting physiological functions more suited to it.	1
The Hardy-Weinberg principle shows that gene pools will remain stable unless mutation, migration, or genetic drift lead to evolutionary change.	2
Possible:	5
Maximum:	4

Teacher Notes

DRAFT

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 05
UNIT NAME: THEORY OF EVOLUTION

TOPIC: Natural Selection
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B051KhSA.01
GUIDELINE OBJECTIVE CODE: 51Kh
INSTRUMENT TYPE: SA
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: populations individual

Guideline Objective

Students will be expected to explain with reference to the gene pool of a population why the theory of biological evolution applies to populations of organisms and not to individuals.

Item Focus

Same as above.

Item

Populations of a species can continue to evolve even though all phenotypes survive to reach reproductive maturity. Name five factors which could influence the evolution of a species under these conditions.

Response/Marking Scheme

Any 5, such as:

alteration of the mating behaviour
time of maturity
alteration of reproductive structures
alteration of the particular habitat in which they survive
hybrid sterility
differential reproductive success of particular phenotypes

Maximum: 5

Teacher Notes

DRAFT

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B051KiMC.01
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 51Ki
UNIT NUMBER: 05	INSTRUMENT TYPE: MC
UNIT NAME: THEORY OF EVOLUTION	KLOPFER: A.1, A.2, A.3, A.8, I.3
	DIFFICULTY LEVEL: L
TOPIC: Hardy-Weinberg Law	TIME ALLOCATION:
CURRICULAR EMPHASIS: Nature of Science	

KEYWORDS: gene frequencies

Guideline Objective

The student will be expected to state the Hardy-Weinberg law, and explain its significance in terms of the development of evolutionary theory.

Item Focus

The student should be able to identify the domain of the Hardy-Weinberg law.

Item

The mathematical relationship of gene frequencies in populations is known as

☐ A. the Watson-Crick model.

☐ B. Darwin's theory.

☐ C. Malthus' theory.

☐ D. the Hardy-Weinberg law.

☐ E. Mendel's law

Response/Marking Scheme

Correct response: D

Teacher Notes

DRAFT

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 05
UNIT NAME: THEORY OF EVOLUTION

TOPIC: Hardy-Weinberg Law
CURRICULAR EMPHASIS: Nature of Science

INSTRUMENT CODE: B051KiMC.02
GUIDELINE OBJECTIVE CODE: 51Ki
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3, A.6, A.8
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: gene frequencies

Guideline Objective

The student will be expected to state the Hardy-Weinberg law, and explain its significance in terms of the development of evolutionary theory.

Item Focus

The student should be able to identify the dependent variable of the Hardy-Weinberg law.

Item

The Hardy-Weinberg law is chiefly concerned with

☐ A. gene frequencies.

☐ B. osmotic phenomena.

☐ C. electron transport.

☐ D. sex-linkage.

☐ E. geographic distribution.

Response/Marking Scheme

Correct response: A

Teacher Notes

DRAFT

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 05
UNIT NAME: THEORY OF EVOLUTION

TOPIC: Hardy-Weinberg Law
CURRICULAR EMPHASIS: Nature of Science

INSTRUMENT CODE: B051KiMC.03
GUIDELINE OBJECTIVE CODE: 51Ki
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3, A.6, A.8
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: gene frequencies

Guideline Objective

The student will be expected to state the Hardy-Weinberg law, and explain its significance in terms of the development of evolutionary theory.

Item Focus

The student should be able to identify the quantity measured by the Hardy-Weinberg law.

Item

The Hardy-Weinberg law enables us to

☐ A. predict genetic ratios from individual matings.

☐ B. map chromosomes.

☐ C. calculate gene frequencies in a population from generation to generation.

☐ D. predict population growth.

☐ E. measure the rate of evolutionary change.

Response/Marking Scheme

Correct response: C

Teacher Notes

DRAFT

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 05
UNIT NAME: THEORY OF EVOLUTION

TOPIC: Hardy-Weinberg Law
CURRICULAR EMPHASIS: Nature of Science

INSTRUMENT CODE: B051KiMC.04
GUIDELINE OBJECTIVE CODE: 51Ki
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3, A.8
DIFFICULTY LEVEL: M
TIME ALLOCATION:

KEYWORDS: gene frequencies

Guideline Objective

The student will be expected to state the Hardy-Weinberg law, and explain its significance in terms of the development of evolutionary theory.

Item Focus

The student should be able to identify the result of violation of the Hardy-Weinberg law.

Item

The Hardy-Weinberg law is based on several assumptions. If any assumption is violated, we would expect

☐ A. p values, but not q values, to change.

☐ B. q values, but not p values, to change.

☐ C. both p and q values to change.

☐ D. neither p nor q values to change.

☐ E. any one of the above to be possible.

Response/Marking Scheme

Correct response: C

Teacher Notes

DRAFT

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B051KiMC.05
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 51Ki
UNIT NUMBER: 05	INSTRUMENT TYPE: MC
UNIT NAME: THEORY OF EVOLUTION	KLOPFER: A.1, A.2, A.3, A.8
	DIFFICULTY LEVEL: M
TOPIC: Hardy-Weinberg Law	TIME ALLOCATION:
CURRICULAR EMPHASIS: Nature of Science	

KEYWORDS: gene frequencies

Guideline Objective

The student will be expected to state the Hardy-Weinberg law, and explain its significance in terms of the development of evolutionary theory.

Item Focus

The student should be able to identify a consequence of the Hardy-Weinberg law.

Item

If the frequencies of genotypes AA, Aa and aa were 0.75, 0.20 and 0.05 respectively in a population 'obeying' the Hardy-Weinberg law, we would expect to observe, over a period of many generations, that

☐ A. the frequencies of heterozygous individuals would increase at the expense of both AA and aa.

☐ B. the frequencies of the recessive gene would decrease and finally be eliminated.

☐ C. the genotype frequencies would show no change.

☐ D. the frequency of the A gene would increase until all individuals were homozygous.

☐ E. the frequencies of the three genotypes would become identical after the first generation and then remain stable.

Response/Marking Scheme

Correct response: C

Teacher Notes

DRAFT

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 05
UNIT NAME: THEORY OF EVOLUTION

TOPIC: Hardy-Weinberg Law
CURRICULAR EMPHASIS: Nature of Science

INSTRUMENT CODE: B051KiMC.06
GUIDELINE OBJECTIVE CODE: 51Ki
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3, A.8
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: gene frequencies

Guideline Objective

The student will be expected to state the Hardy-Weinberg law, and explain its significance in terms of the development of evolutionary theory.

Item Focus

The student should be able to identify the Hardy-Weinberg equation.

Item

Which of the following is always true of the two alleles A and a in a Hardy-Weinberg population?

☐ A. $p^2 + 2pq + q^2 = 1$

☐ B. $p + q = 1$

☐ C. $q = 1 - p$

☐ D. $p - q = 0$

☐ E. $p = 1 - q^2$

Response/Marking Scheme

Correct response: A

Teacher Notes

DRAFT

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 05
UNIT NAME: THEORY OF EVOLUTION

TOPIC: Hardy-Weinberg Law
CURRICULAR EMPHASIS: Nature of Science

INSTRUMENT CODE: B051KiMC.07
GUIDELINE OBJECTIVE CODE: 51Ki
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3, A.8, C.3, D.5
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: gene frequencies

Guideline Objective

The student will be expected to state the Hardy-Weinberg law, and explain its significance in terms of the development of evolutionary theory.

Item Focus

The student should be able to identify the result of a population conforming to the conditions of the Hardy-Weinberg law.

Item

A population of wild rats obeying the Hardy-Weinberg law with respect to coat colour would be expected to

- ☐ A. increase the proportion of dominant phenotypes.
- ☐ B. increase the proportion of heterozygotes.
- ☐ C. increase the proportion of homozygous recessives.
- ☐ D. maintain a constant proportion of coat colour in the population from generation to generation.
- ☐ E. eliminate heterozygosity.

Response/Marking Scheme

Correct response : D

Teacher Notes

DRAFT

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 05
UNIT NAME: THEORY OF EVOLUTION

TOPIC: Hardy-Weinberg Law
CURRICULAR EMPHASIS: Nature of Science

INSTRUMENT CODE: B051KiMC.08
GUIDELINE OBJECTIVE CODE: 51Ki
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3, A.8, C.3, D.5
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: gene frequencies

Guideline Objective

The student will be expected to state the Hardy-Weinberg law, and explain its significance in terms of the development of evolutionary theory.

Item Focus

The student should be able to identify an observation that is consistent with Hardy-Weinberg law.

Item

Which of the following best illustrates the Hardy-Weinberg law?

☐ A. The coats of Arctic hares are white in winter and brown in summer.

☐ B. Jurassic dinosaurs tended to be larger than Triassic dinosaurs.

☐ C. Native amphibians do not occur on many Pacific Islands.

☐ D. The proportion of blue-eyed to brown-eyed people in the world has not greatly changed in the last ten generations.

☐ E. The populations of hawks and mice go through similar cyclic changes with the hawks slightly later in phase.

Response/Marking Scheme

Correct response: D

Teacher Notes

DRAFT

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B051KiMC.10
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 51Ki
UNIT NUMBER: 05	INSTRUMENT TYPE: MC
UNIT NAME: THEORY OF EVOLUTION	KLOPFER: A.1, A.2, A.3, A.8
	DIFFICULTY LEVEL: L
TOPIC: Hardy-Weinberg Law	TIME ALLOCATION:
CURRICULAR EMPHASIS: Nature of Science	

KEYWORDS: gene frequencies

Guideline Objective

The student will be expected to state the Hardy-Weinberg law, and explain its significance in terms of the development of evolutionary theory.

Item Focus

The student should be able to identify the meaning of the Hardy-Weinberg equation.

Item

The expression, $p^2 + 2pq + q^2 = 1$, in genetics states that

☐ A. mutations are the raw materials for evolution.

☐ B. during migration, genes do not mate at random.

☐ C. differential reproduction provides an advantage to certain genotypes.

☐ D. under certain conditions, gene frequencies in a population remain constant from generation to generation.

☐ E. under certain conditions, gene frequencies in a population vary from generation to generation.

Response/Marking Scheme

Correct response: D

Teacher Notes

DRAFT

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B051KiMC.11
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 51Ki
UNIT NUMBER: 05	INSTRUMENT TYPE: MC
UNIT NAME: THEORY OF EVOLUTION	KLOPFER: A.1, A.2, A.3, A.8, I.3
	DIFFICULTY LEVEL: L
TOPIC: Hardy-Weinberg Law	TIME ALLOCATION:
CURRICULAR EMPHASIS: Nature of Science	

KEYWORDS: gene frequencies

Guideline Objective

The student will be expected to state the Hardy-Weinberg law, and explain its significance in terms of the development of evolutionary theory.

Item Focus

The student should be able to identify Hardy and Weinberg as the discoverers of the law involving gene frequencies.

Item

The expression $p^2 + 2pq + q^2 = 1$ for gene frequencies was proposed by:

☐ A. Darwin and Wallace

☐ B. Morgan and Sutton

☐ C. Avery and Griffiths

☐ D. Laurel and Hardy

☐ E. Hardy and Weinberg

Response/Marking Scheme

Correct response: E

Teacher Notes

DRAFT

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 05
UNIT NAME: THEORY OF EVOLUTION

TOPIC: Hardy-Weinberg Law
CURRICULAR EMPHASIS: Nature of Science

INSTRUMENT CODE: B051KiMC.14
GUIDELINE OBJECTIVE CODE: 51Ki
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3, A.8
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: population genetics

Guideline Objective

The student will be expected to state the Hardy-Weinberg law, and explain its significance in terms of the development of evolutionary theory.

Item Focus

The student should be able to recognize a definition of the Hardy-Weinberg law.

Item

The Hardy-Weinberg law states that

☐ A. all populations evolve at the same rate.

☐ B. recessive genes will be eliminated from the population.

☐ C. those individuals with more favourable characteristics will survive.

☐ D. populations with constant genotypic ratios will not evolve.

☐ E. homozygous recessive individuals are eliminated from a population.

Response/Marking Scheme

Correct response: D

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 05
UNIT NAME: THEORY OF EVOLUTION

TOPIC: Hardy-Weinberg Law
CURRICULAR EMPHASIS: Nature of Science

INSTRUMENT CODE: B051KiMC.15
GUIDELINE OBJECTIVE CODE: 51Ki
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.8
DIFFICULTY LEVEL: M
TIME ALLOCATION:

KEYWORDS: gene frequencies

Guideline Objective

The student will be expected to state the Hardy-Weinberg law, and explain its significance in terms of the development of evolutionary theory.

Item Focus

The student should be able to identify a statement of the Hardy-Weinberg law.

Item

Which of the following is a significant consequence of the Hardy-Weinberg law?

☐ A. Only one member of a pair of homologous chromosomes enters a gamete.

☐ B. The number of nitrogen bases on a strand of a DNA molecule required to synthesize one enzyme makes up one gene.

☐ C. The frequency of the recessive form of a trait in a population will be reduced with each successive generation.

☐ D. Under certain conditions the frequency of a pair of alleles (eg. A and a) in a population will remain the same indefinitely.

☐ E. Either member of a pair of homologous chromosomes may enter a gamete with either member of any other pair of homologous chromosomes.

Response/Marking Scheme

Correct response: D

Teacher Notes

DRAFT

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B051KiMC.16
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 51Ki
UNIT NUMBER: 05	INSTRUMENT TYPE: MC
UNIT NAME: THEORY OF EVOLUTION	KLOPFER: A.1, A.2, A.3
	DIFFICULTY LEVEL: L
TOPIC: Hardy-Weinberg Law	TIME ALLOCATION:
CURRICULAR EMPHASIS: Nature of Science	

KEYWORDS: population genetics

Guideline Objective

The student will be expected to state the Hardy-Weinberg law, and explain its significance in terms of the development of evolutionary theory.

Item Focus

The student should be able to identify the reason that recessive alleles are maintained in a population.

Item

One might think that, if a gene in its homozygous recessive state were lethal, it would disappear from the population within several generations. This does not happen because

☐ A. of the Law of Independent Assortment.

☐ B. the recessive allele is masked in the heterozygous state.

☐ C. not all of the homozygous recessives die.

☐ D. chromosomal aberrations compensate for the lethal allele.

☐ E. multiple gene inheritance hides the effects of the lethal allele.

Response/Marking Scheme

Correct response: B

Teacher Notes

DRAFT

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 05
UNIT NAME: THEORY OF EVOLUTION

TOPIC: Hardy-Weinberg Law
CURRICULAR EMPHASIS: Nature of Science

INSTRUMENT CODE: B051KiMC.17
GUIDELINE OBJECTIVE CODE: 51Ki
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: population genetics

Guideline Objective

The student will be expected to state the Hardy-Weinberg law, and explain its significance in terms of the development of evolutionary theory.

Item Focus

The student should be able to recognize the conditions necessary for the Hardy-Weinberg law to operate.

Item

Four of the following conditions are necessary for the Hardy-Weinberg law to operate. Which one should be excluded?

☐ A. There is no migration into or out of the population.

☐ B. Natural selection does not occur.

☐ C. The population breeds at random.

☐ D. The gene frequencies are the same in males and females.

☐ E. There is an increase in the frequency of the dominant allele.

Response/Marking Scheme

Correct response: E

Teacher Notes

DRAFT

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B051KiMC.18
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 51Ki
UNIT NUMBER: 05	INSTRUMENT TYPE: MC
UNIT NAME: THEORY OF EVOLUTION	KLOPFER: A.1, A.2, A.8
	DIFFICULTY LEVEL: M
TOPIC: Hardy-Weinberg Law	TIME ALLOCATION:
CURRICULAR EMPHASIS: Nature of Science	

KEYWORDS: natural selection

Guideline Objective

The student will be expected to state the Hardy-Weinberg law, and explain its significance in terms of the development of evolutionary theory.

Item Focus

The student should be able to identify the influence of certain factors on the Hardy-Weinberg equilibrium.

Item

Provided that certain conditions are maintained, the Hardy-Weinberg law states that a pair of alleles in a population (eg. D and d), will remain at the same frequency indefinitely. Under which of the following conditions would the application of the Hardy-Weinberg Law be inappropriate?

- [ ] A. The population reproduces sexually, by random mating.
- [ ] B. Natural selection occurs amongst the members of the population.
- [ ] C. No mutations occur.
- [ ] D. The population is very large.
- [ ] E. The population is completely isolated from any other population of the same species.

Response/Marking Scheme

Correct response: B

Teacher Notes

DRAFT

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B051KiER.02
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 51Ki
UNIT NUMBER: 05	INSTRUMENT TYPE: ER
UNIT NAME: THEORY OF EVOLUTION	KLOPFER: A.1, A.2
	DIFFICULTY LEVEL: M
TOPIC: Hardy-Weinberg Law	TIME ALLOCATION:
CURRICULAR EMPHASIS: Solid Foundations	

KEYWORDS: sickle cell anemia.

Guideline Objective

The student will be expected to state the Hardy-Weinberg law, and explain its significance in terms of the development of evolutionary theory.

Item Focus

The student should be able to explain the presence of the sickle cell anemia allele in a population.

Item

Sickle cell anemia is a genetic disease which is caused by recessive alleles. Usually, a person homozygous for the sickle cell allele dies early in life. Heterozygotes are essentially normal. At the same time, the frequency of this allele in the black population of Africa is maintained. Explain this occurrence.

Response/Marking Scheme

If the deleterious allele is being maintained in the population, then it must	
not be selected against in	1
its heterozygous state.	1
It has been found that individuals who carry one allele	1
for sickle cell anemia, have a resistance to malaria,	1
a disease in Africa. This is the actual advantage which is provided by the allele	
in its heterozygous state.	

Possible: 4

Maximum: 4

Teacher Notes

DRAFT

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B051KiER.03
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 51Ki
UNIT NUMBER: 05	INSTRUMENT TYPE: ER
UNIT NAME: THEORY OF EVOLUTION	KLOPFER: A.1, A.2, A.3, A.10
	DIFFICULTY LEVEL: M
TOPIC: Hardy-Weinberg Law	TIME ALLOCATION:
CURRICULAR EMPHASIS: Solid Foundations	

KEYWORDS: genotype phenotype.

Guideline Objective

The student will be expected to state the Hardy-Weinberg law, and explain its significance in terms of the development of evolutionary theory.

Item Focus

The student should be able to explain the adaptive genotypes in a population.

Item

In each of the following unrelated situations, explain how the adaptive value of the genotype will affect the phenotypes present in the population.

A. AA is better adapted than Aa, and Aa is better adapted than aa.

B. AA and Aa have equal chances at survival and both are better adapted than aa.

C. Aa is better adapted than either AA or aa.

Response/Marking Scheme

A. The phenotype for aa should slowly decline from the population and with time, the population should increase in AA.	2
B. The phenotype for aa should decline. This reduces	1
the frequency of a for that population, with fewer	1
individuals of Aa being formed. This will reduce the	1
chance of Aa × Aa, so that aawill occur less often.	1
C. Since Aa is maintained in the population because of its high adaptive value both AA and aa will be maintained.	1

Possible: 7

Maximum: 5

DRAFT

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 05
UNIT NAME: THEORY OF EVOLUTION

TOPIC: Hardy-Weinberg Law
CURRICULAR EMPHASIS: Nature of Science

INSTRUMENT CODE: B051KiER.04
GUIDELINE OBJECTIVE CODE: 51Ki
INSTRUMENT TYPE: ER
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: gene frequencies

Guideline Objective

The student will be expected to state the Hardy-Weinberg law, and explain its significance in terms of the development of evolutionary theory.

Item Focus

Same as above.

Item

Explain how Hardy and Weinberg contributed to the theory of evolution.

Response/Marking Scheme

They formulated the mathematical relationship that	1
demonstrated that gene pools	1
should not change	1
from generation to generation,	1
if mating is random, and no selection pressures occur.	2
The factors that disturb this equilibrium	1
lead to evolution.	1
Possible:	8
Maximum:	6

Teacher Notes

DRAFT

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B051KiER.05
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 51Ki
UNIT NUMBER: 05	INSTRUMENT TYPE: ER
UNIT NAME: THEORY OF EVOLUTION	KLOPFER: A.1, A.2, A.10, A.11, C.1, D.3, D.6, F.1
TOPIC: Hardy-Weinberg Law	DIFFICULTY LEVEL: M
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:

KEYWORDS: population genetics

Guideline Objective

The student will be expected to state the Hardy-Weinberg law, and explain its significance in terms of the development of evolutionary theory.

Item Focus

The student should be able to calculate the proportion of a particular allele in a population.

Item

In Holstein cattle, one calf in 100 is spotted red, rather than black. Redness is due to a recessive allele. What proportion of Holsteins are heterozygous?

Response/Marking Scheme

Frequency of red allele in the population:

$q^2 = 0.01$	1
$q = 0.1$	1

Frequency of the dominant allele in the population:

$p = 1 - 0.1 = 0.9$	2

Therefore, the number of heterozygotes in the population:

$= 2(0.1)(0.9) = 2(0.09)$	1
$= 18\%$	1

Possible: 6

Maximum: 6

Teacher Notes

DRAFT

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B051KiER.06
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 51Ki
UNIT NUMBER: 05	INSTRUMENT TYPE: ER
UNIT NAME: THEORY OF EVOLUTION	KLOPFER: A.1, A.2, A.3, A.5, A.8.
	DIFFICULTY LEVEL: M
TOPIC: Hardy-Weinberg Law	TIME ALLOCATION:
CURRICULAR EMPHASIS: Nature of Science	

KEYWORDS: gene pool

Guideline Objective

The student will be expected to state the Hardy-Weinberg law, and explain its significance in terms of the development of evolutionary theory.

Item Focus

Same as above.

Item

A. State the Hardy-Weinberg Law.

B. Explain how the Hardy-Weinberg Law relates to the process of evolution.

Response/Marking Scheme

A. In a population breeding at random, the proportions of genotypes and phenotypes remain unchanged, generation after generation, if certain conditions hold: 4

1. the population is very large

2. that both alleles of a gene are adaptively neutral

3. that there is no immigration or emigration

4. and that there is no mutation. 4

B. These assumptions are extremely unlikely. 1

In most populations one or more of the assumed conditions will vary. Therefore, mutation, genetic drift, and natural selection do contribute to evolution, as would be expected from the Hardy-Weinberg Law. 4

Possible: 13

Maximum: 10

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 05
UNIT NAME: THEORY OF EVOLUTION

TOPIC: The Hardy-Weinberg Law
CURRICULAR EMPHASIS: Nature of Science

INSTRUMENT CODE: B051KiER.07
GUIDELINE OBJECTIVE CODE: 51Ki
INSTRUMENT TYPE: ER
KLOPFER: A.1, A.2, A.3, A.5.
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS:

Guideline Objective

The student will be expected to state the Hardy-Weinberg law, and explain its significance in terms of the development of evolutionary theory.

Item Focus

Same as above.

Item

List four conditions necessary for the Hardy-Weinberg law to apply.

Response/Marking Scheme

Any four of the following:

1. The population is large enough to have a large gene pool.
2. Mating is random: there are no mating preferences.
3. There are no mutations.
4. The population does not gain or lose individuals through immigration or emigration.
5. Reproduction is random: there is no differential reproduction due to differences in such factors as fecundity.

Possible: 4

Maximum: 4

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B051KiER.08
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 51Ki
UNIT NUMBER: 05	INSTRUMENT TYPE: ER
UNIT NAME: THEORY OF EVOLUTION	KLOPFER: A.1, A.2, A.3, A.8
	DIFFICULTY LEVEL: M
TOPIC: Hardy-Weinberg Law	TIME ALLOCATION:
CURRICULAR EMPHASIS: Nature of Science	

KEYWORDS: migration mutation genetic drift

Guideline Objective

The student will be expected to state the Hardy-Weinberg law, and explain its significance in terms of the development of evolutionary theory.

Item Focus

The student will explain how such factors as migration, mutation, and genetic drift violate the Hardy-Weinberg law and lead to evolution.

Item

The Hardy-Weinberg law maintains that if certain factors remain constant, the gene pool of a population will not change. Yet gene pools do change. Discuss the role of each of the following factors on gene pools:

A. migration,

B. mutation,

C. genetic drift.

Response/Marking Scheme

A. Individuals may migrate into or out of a population. 2

Thus their genes are either added to, or lost from 2

the gene pool. If large numbers leave or arrive, the proportions of alleles in the gene pool will change. 1

B. Certain genes change spontaneously from one allele 1

to another. Reverse mutation also occurs. 1

Both of these changes will alter the proportion of 1

the alleles in the gene pool. Many mutations are harmful, reducing the survival potential of the individual, and affecting the gene pool. 2

C. In a small gene pool, the death of individuals with 1

particular alleles causes an accidental or random 2

change in the gene pool that may make a proportionately large change in the gene frequency. 2

Maximum: 5 each part × 3 = 15

Teacher Notes

DRAFT

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B051KiMA.01
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 51Ki
UNIT NUMBER: 05	INSTRUMENT TYPE: MA
UNIT NAME: THEORY OF EVOLUTION	KLOPFER: A.1, A.2, A.3, A.8
TOPIC: Hardy-Weinberg Law	DIFFICULTY LEVEL: M
CURRICULAR EMPHASIS: Nature of Science	TIME ALLOCATION:

KEYWORDS: Hardy-Weinberg law migration mutation genetic drift natural selection sexual selection.

Guideline Objective

The student will be expected to state the Hardy-Weinberg law, and explain its significance in terms of the development of evolutionary theory.

Item Focus

The student should be able to identify factors that violate the Hardy-Weinberg law and their meanings.

Item

In the list at the left are six factors that affect the frequency of alleles in the gene pools of populations, contributing to evolution. In the blank to the left of each factor, insert the number of the phrase that best describes it.

_____ A. immigration

_____ B. emigration

_____ C. mutation

_____ D. genetic drift

_____ E. sexual selection

_____ F. natural selection

1. One allele changes spontaneously to a different form.
2. Several different alleles of the same gene occurs in a gene pool.
3. Females choose mates possessing a particular trait.
4. In small populations, random fluctuations in frequency of certain genes may occur.
5. When a small population finds a new island habitat, its gene pool may differ from that of its parent population.
6. Individuals moving into a population bring different alleles.
7. Predators affect the gene frequency of a population by eating more individuals with conspicuous traits.
8. Variations are the result of the interaction of the genes and the environment.
9. Individuals move away from a population taking particular alleles out of the gene pool.

Response/Marking Scheme

Correct answers:

A. 6, B. 9, C. 1, D. 4, E. 3, F. 7

Maximum: 6

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B051KiSA.01
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 51Ki
UNIT NUMBER: 05	INSTRUMENT TYPE: SA
UNIT NAME: THEORY OF EVOLUTION	KLOPFER: A.1, A.2, A.5, A.11, D.1, D.3, I.2
TOPIC: Hardy-Weinberg Law	DIFFICULTY LEVEL: M
CURRICULAR EMPHASIS: Nature of Science	TIME ALLOCATION:

KEYWORDS: natural selection gene frequencies

Guideline Objective

The student will be expected to state the Hardy-Weinberg law, and explain its significance in terms of the development of evolutionary theory.

Item Focus

The student should be able to explain how such factors as migration, mutation and genetic drift violate the Hardy-Weinberg law.

Item

Refer to Figure 5K.13.

CHANGES IN GENE FREQUENCY OF A POPULATION OF DROSOPHILA OVER TIME

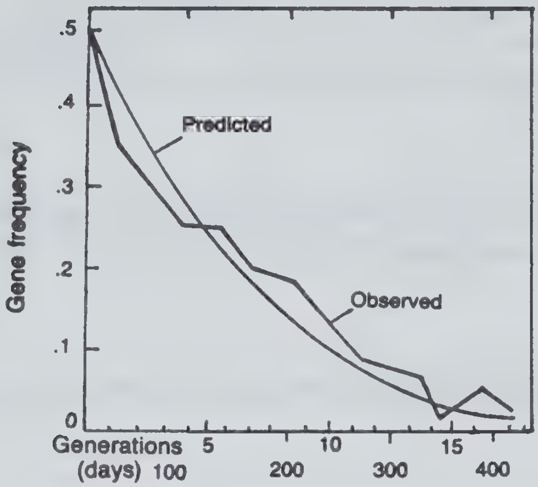


Figure 5K.13 represents observed and predicted results in the changes in gene frequency of a population of raspberry-eyed *Drosophila* which have been released into a population of wild *Drosophila*.

A. Explain the reasons for the differences between observed and predicted results.

B. What might explain the reduction in frequency of the allele from the population?

Response/Marking Scheme

A. The difference between the observed and predicted results is caused by the fact that, in reality, the rate at which the allele disappears from the population is irregular (or due to experimental error). 1
The trend, however, remains the same as predicted 1
(i.e. the data must be very good to approximate the predicted curve).

B. Since the allele is disappearing from the population, it must in some way affect the rate of reproduction or survival of the flies which have the phenotype, or the offspring of these flies must in some way be affected. 2

Possible: 4

Maximum: 4

DRAFT

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 05
UNIT NAME: THEORY OF EVOLUTION

TOPIC: Hardy-Weinberg Law
CURRICULAR EMPHASIS: Nature of Science

INSTRUMENT CODE: B051KiSA.02
GUIDELINE OBJECTIVE CODE: 51Ki
INSTRUMENT TYPE: SA
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: populations

Guideline Objective

The student will be expected to state the Hardy-Weinberg law, and explain its significance in terms of the development of evolutionary theory.

Item Focus

The student should be able to state the causes of genotypic changes in a population.

Item

In *Drosophila*, if a number of raspberry-eyed flies are released into a wild population, over time, the raspberry colour disappears from the population. Suggest two reasons for the reduction in frequency of the trait.

Response/Marking Scheme

Since the allele is disappearing from the population, it must in some way affect the rate of reproduction or survival of the flies which have the phenotype, or the offspring of these flies must in some way be affected. 2

Possible: 2

Maximum: 2

Teacher Notes

DRAFT

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 05
UNIT NAME: THEORY OF EVOLUTION
TOPIC: Hardy-Weinberg Law
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B051KiSA.03
GUIDELINE OBJECTIVE CODE: 51Ki
INSTRUMENT TYPE: SA
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: natural selection

Guideline Objective

The student will be expected to state the Hardy-Weinberg law, and explain its significance in terms of the development of evolutionary theory.

Item Focus

The student should be able to explain the effect of a deleterious allele in a gene pool.

Item

Explain how a harmful allele might be maintained in a population.

Response/Marking Scheme

Even though a gene may have harmful effects to a population, it may be retained in the population in the following conditions:

1. If the allele is harmful in its homozygous form, but is not expressed in the heterozygous form. 1
2. If the allele does not take effect until after the normal reproductive age. 1

Possible: 2

Maximum: 2

Teacher Notes

DRAFT

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 05
UNIT NAME: THEORY OF EVOLUTION

TOPIC: Genetic Variability
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B051KjMC.01
GUIDELINE OBJECTIVE CODE: 51Kj
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3, A.5
DIFFICULTY LEVEL: M
TIME ALLOCATION:

KEYWORDS:

Guideline Objective

Students will be expected to describe three or more of the mechanisms that can lead to genetic variation in a population, e.g. mutation, natural selection, genetic drift, gene flow (migration) and population increase and decrease.

Item Focus

The student should be able to identify an example of continuous genetic variation in a population.

Item

Which of the following would be an example of a continuous pattern of genetic variation?

☐ A. length of ears in a rabbit population

☐ B. wing colouration in peppered moths

☐ C. sex genotypes of humans

☐ D. ABO blood types in humans

☐ E. height in a population of pea plants

Response/Marking Scheme

Correct response: A

Teacher Notes

DRAFT

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B051KjMC.02
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 51Kj
UNIT NUMBER: 05	INSTRUMENT TYPE: MC
UNIT NAME: THEORY OF EVOLUTION	KLOPFER: A.1, A.2, A.3, A.8
	DIFFICULTY LEVEL: L
TOPIC: Genetic Variation	TIME ALLOCATION:
CURRICULAR EMPHASIS: Solid Foundations	

KEYWORDS: sexual reproduction

Guideline Objective

Students will be expected to describe three or more of the mechanisms that can lead to genetic variation in a population, e.g. mutation, natural selection, genetic drift, gene flow (migration) and population increase and decrease.

Item Focus

The student should be able to recognize reasons for genetic variation.

Item

Evolution can take place more rapidly among organisms which reproduce sexually than among organisms which reproduce asexually because

- [ ] A. sexual reproduction is more hazardous than asexual, hence, only the fit survive.
- [ ] B. asexual reproduction is more common in one-celled organisms.
- [ ] C. sexual reproduction is more likely to produce a variety of offspring.
- [ ] D. sexual reproduction is slower than asexual reproduction in producing offspring.
- [ ] E. sexual reproduction is more rapid than asexual reproduction in producing offspring.

Response/Marking Scheme

Correct response: C

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 05
UNIT NAME: THEORY OF EVOLUTION

TOPIC: Genetic Variability
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B051KjMC.03
GUIDELINE OBJECTIVE CODE: 51Kj
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: populations

Guideline Objective

Students will be expected to describe three or more of the mechanisms that can lead to genetic variation in a population, e.g. mutation, natural selection, genetic drift, gene flow (migration) and population increase and decrease.

Item Focus

The student should be able to identify the factors that contribute to the variability of a population.

Item

Four of the following contribute to the variability of a population. Which one does NOT add variability?

☐ A. sexual reproduction

☐ B. mutation

☐ C. mitosis

☐ D. meiosis

☐ E. natural selection

Response/Marking Scheme

Correct response: C

Teacher Notes

DRAFT

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 05
UNIT NAME: THEORY OF EVOLUTION

TOPIC: Genetic Variability
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B051KjMC.04
GUIDELINE OBJECTIVE CODE: 51Kj
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: sexual reproduction

Guideline Objective

Students will be expected to describe three or more of the mechanisms that can lead to genetic variation in a population, e.g. mutation, natural selection, genetic drift, gene flow (migration) and population increase and decrease.

Item Focus

The student should be able to identify the major source of genetic variation in populations.

Item

In a population, genetic variations arise mainly as a result of

☐ A. continuing adaptation of body parts through use.

☐ B. interbreeding with unrelated species.

☐ C. different rates of reproduction.

☐ D. asexual reproduction.

☐ E. sexual recombination.

Response/Marking Scheme

Correct response: E

Teacher Notes

DRAFT

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B051KjMC.05
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 51Kj
UNIT NUMBER: 05	INSTRUMENT TYPE: MC
UNIT NAME: THEORY OF EVOLUTION	KLOPFER: A.1, A.2, A.3
	DIFFICULTY LEVEL: L
TOPIC: Adaptive Radiation	TIME ALLOCATION:
CURRICULAR EMPHASIS: Solid Foundations	

KEYWORDS:

Guideline Objective

Students will be expected to describe three or more of the mechanisms that can lead to genetic variation in a population, e.g. mutation, natural selection, genetic drift, gene flow (migration) and population increase and decrease.

Item Focus

The student should be able to identify aspects of adaptive radiation.

Item

Which one of the following statements about adaptive radiation is true?

☐ A. It can be seen only in morphological features.

☐ B. It occurs mostly in organisms that can fly.

☐ C. All finches have resulted from the process.

☐ D. The process is specific to the Galapagos Islands.

☐ E. Adaptive radiation is the result of evolution.

Response/Marking Scheme

Correct response: A

Teacher Notes

DRAFT

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 05
UNIT NAME: THEORY OF EVOLUTION

TOPIC: Speciation
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B051KjMC.06
GUIDELINE OBJECTIVE CODE: 51Kj
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: isolating mechanisms

Guideline Objective

Students will be expected to describe three or more of the mechanisms that can lead to genetic variation in a population, e.g. mutation, natural selection, genetic drift, gene flow (migration) and population increase and decrease.

Item Focus

The student should be able to identify three isolating mechanisms that may result in speciation.

Item

Three isolating mechanisms that may result in the production of new species are

☐ A. natural selection, sexual selection, descent with modifications.

☐ B. comparative biochemistry, comparative morphology, comparative embryology.

☐ C. adaptive radiation, vestigial structures, paleontology.

☐ D. geographical barriers, reproductive barriers, different mating seasons.

☐ E. migration, mutation, variability.

Response/Marking Scheme

Correct response: D

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B051KjMC.07
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 51Kj
UNIT NUMBER: 05	INSTRUMENT TYPE: MC
UNIT NAME: THEORY OF EVOLUTION	KLOPFER: A.1, A.2, A.3
	DIFFICULTY LEVEL: L
TOPIC: Mutations	TIME ALLOCATION:
CURRICULAR EMPHASIS: Solid Foundations	

KEYWORDS: DNA

Guideline Objective

Students will be expected to describe three or more of the mechanisms that can lead to genetic variation in a population, e.g. mutation, natural selection, genetic drift, gene flow (migration) and population increase and decrease.

Item Focus

The student should be able to identify aspects of mutation.

Item

Which one of the following best describes mutations?

☐ A. They are changes in the DNA

☐ B. They are physical variations caused by the environment.

☐ C. Most of them are harmless.

☐ D. They usually involve drastic reorganization of the organism.

☐ E. They are restricted to the gametes.

Response/Marking Scheme

Correct response: A

Teacher Notes

DRAFT

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 05
UNIT NAME: THEORY OF EVOLUTION

TOPIC: Genetic Variability
CURRICULAR EMPHASIS: Nature of Science

INSTRUMENT CODE: B051KjMC.09
GUIDELINE OBJECTIVE CODE: 51Kj
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3, A.9, D.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: species electrophoresis graphical analysis

Guideline Objective

Students will be expected to describe three or more of the mechanisms that can lead to genetic variation in a population, e.g. mutation, natural selection, genetic drift, gene flow (migration) and population increase and decrease.

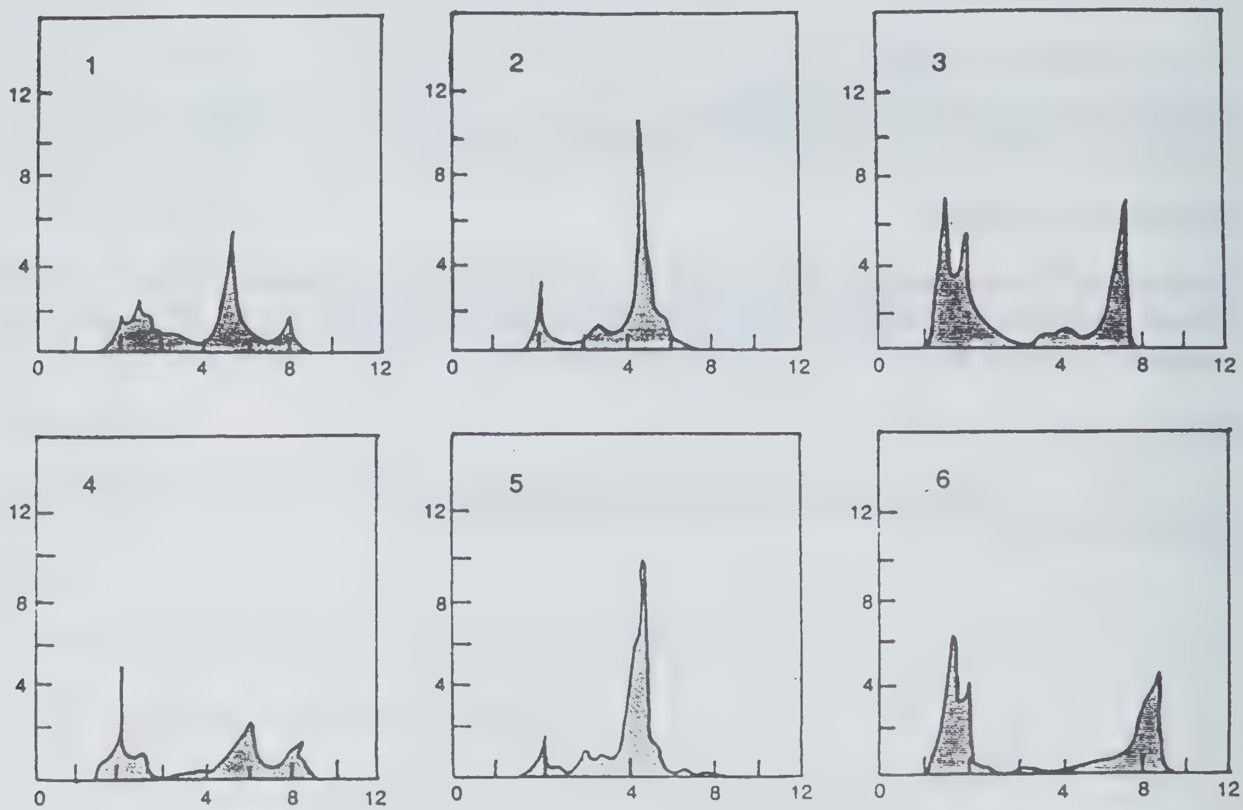
Item Focus

The student should be able to identify similar electrophoretic patterns as an indication of a close relationship.

Item

Refer to Figure 5K.14.

ELECTROPHORETIC PATTERNS OF THE EGG PROTEINS OF BIRDS



Biochemists can sometimes tell how closely related two species are, in an evolutionary sense, by comparing homologous proteins. Figure 5K.14 shows the drawings of electrophoretic patterns of the egg proteins of various birds. Which two are most likely to be two birds of the same genus?

☐ A. 1 and 2

☐ B. 2 and 5

☐ C. 1 and 4

☐ D. 4 and 6

☐ E. 3 and 6

Response/Marking Scheme

Correct response: B

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 05
UNIT NAME: THEORY OF EVOLUTION

TOPIC: Speciation
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B051KjMC.10
GUIDELINE OBJECTIVE CODE: 51Kj
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3, A.5
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: species mutations

Guideline Objective

Students will be expected to describe three or more of the mechanisms that can lead to genetic variation in a population, e.g. mutation, natural selection, genetic drift, gene flow (migration) and population increase and decrease.

Item Focus

The student should be able to identify the contribution mutations make to speciation.

Item

Which one of the following describes how mutations contribute to speciation?

☐ A. They improve the structure and functioning of an organism so that it can advance to a new evolutionary stage.

☐ B. They change a gene, making it impossible for the individual to interbreed within its previous gene pool.

☐ C. Most mutations are irrelevant or harmful, but occasionally one contributes to an adaptation, and gradually spreads through the gene pool.

☐ D. Mutations are always harmful, creating deformed monsters that are unable to survive until they reach reproductive maturity.

☐ E. Organisms with a new mutation are likely to be sterile; the sterility barrier separates one species from another.

Response/Marking Scheme

Correct response: C

Teacher Notes

DRAFT

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B051KjER.01
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 51Kj
UNIT NUMBER: 05	INSTRUMENT TYPE: ER
UNIT NAME: THEORY OF EVOLUTION	KLOPFER: A.1, A.2, A.3, D.3
	DIFFICULTY LEVEL: M
TOPIC: Genetic Variability	TIME ALLOCATION:
CURRICULAR EMPHASIS: Nature of Science	

KEYWORDS: phenotype.

Guideline Objective

Students will be expected to describe three or more of the mechanisms that can lead to genetic variation in a population, e.g. mutation, natural selection, genetic drift, gene flow (migration) and population increase and decrease.

Item Focus

The student should be able to discuss species variability with respect to plants and humans.

Item

When Mendel formulated his laws of genetics, he worked with pea plants that displayed only two phenotypes for height: tall and dwarf. In contrast, humans display many heights in a population, with the phenotypes falling in a "normal distribution" curve of continuous variation.

Explain the possible reason for this difference between peas and humans, and suggest one possible evolutionary advantage for each of the height distributions.

Response/Marking Scheme

The pea plant has only one gene for height,	1
and this exists in two alleles, tall and dwarf.	1
Because tallness is dominant over dwarfness,	1
heterozygotes will have the tall phenotype.	1
Humans have many genes that influence height,	1
and some of these may be multi-allelic.	1
Incomplete dominance leads to many intermediate heights.	1
Natural selection works on phenotypes, not genotypes.	1
The human distribution has the advantage of providing more phenotypes for natural selection to work on.	1
The pea plant has the possible advantage that tall plants may be exposed to more sunlight, and thus able to trap more energy. On the other hand, dwarf plants are more suited to survive in windy locations, where tall plants might be damaged. (OR ACCEPT ANY PLAUSIBLE ADVANTAGES)	2

Possible: 11

Maximum: 8

Teacher Notes

DRAFT

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 05
UNIT NAME: THEORY OF EVOLUTION

TOPIC: Speciation
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B051KjER.02
GUIDELINE OBJECTIVE CODE: 51Kj
INSTRUMENT TYPE: ER
KLOPFER: A.1, A.2, A.3, A.9
DIFFICULTY LEVEL: M
TIME ALLOCATION:

KEYWORDS: isolating mechanisms.

Guideline Objective

Students will be expected to describe three or more of the mechanisms that can lead to genetic variation in a population, e.g. mutation, natural selection, genetic drift, gene flow (migration) and population increase and decrease.

Item Focus

The student should be able to define speciation and describe isolating mechanisms which contribute to speciation.

Item

A. What is speciation and how does it occur?

B. Describe three isolating mechanisms and show how each might contribute to speciation.

Response/Marking Scheme

A.	Speciation, the formation of new species, may occur when	1
	two or more populations of a parent species become	1
	separated so that their gene pools are not	2
	in active interchange.	1
B.	Any 3 mechanisms @ 3 marks each.	9

1. Geographical barriers that prevent members of two populations from mating, for example, a wide expanse of ocean between islands.

2. Adaptation to different ecological conditions, for example, one population may live on higher, drier mountains than another, and may not seek out mates from a population living in deep moist valleys.

3. Behaviour isolation may result when one population mates in the spring while another mates in the fall.

4. Morphological differences may prevent matings between different variants of the same species. For example, the great dane and the chihuahua are both members of the same species, *Canis familiaris*, but size differences may prevent copulation. In time, they could become 2 different species.

5. Genetic incompatibility may arise to prevent the successful mating of 2 members of different populations.
   For example, sperms from one population of frog may be unable to fertilize the eggs of a different population.

   (Other acceptable mechanisms are hybrid inviability, and hybrid sterility.)

Possible: 14

Maximum: 14

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B051KjER.03
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 51Kj
UNIT NUMBER: 05	INSTRUMENT TYPE: ER
UNIT NAME: THEORY OF EVOLUTION	KLOPFER: A.1, A.2, A.3, A.8, A.9.
	DIFFICULTY LEVEL: M
TOPIC: Natural Selection	TIME ALLOCATION:
CURRICULAR EMPHASIS: Solid Foundations	

KEYWORDS: peppered moth

Guideline Objective

Students will be expected to describe three or more of the mechanisms that can lead to genetic variation in a population, e.g. mutation, natural selection, genetic drift, gene flow (migration) and population increase and decrease.

Item Focus

The student will describe the colour change in a population of peppered moths and explain in terms of natural selection.

Item

Describe the process of natural selection in terms of the population of peppered moths.

Response/Marking Scheme

All peppered moths have the necessary gene to produce dark pigment.	1
The distribution of pigment depends on another gene.	2
The "normal" moth has patches of black on a white	1
background. The "melanic" form has the gene for uniform distribution of pigment.	1
In "normal" populations, the melanic gene is always developing spontaneously by means of mutation.	2
The degree to which "normal" or "melanic" moths survive within a particular population depends on natural selection.	1
According to Kettlewell, the agents of selection are birds, which pluck exposed moths off tree trunks	2
where the moths remain at rest during the daylight.	1
In non-industrial areas, tree trunks have a mottled light and dark appearance, due to the growth of lichens.	2
Here, "normal" moths are less conspicuous than melanic	1
forms, and birds eat most melanic moths	1
before they can reproduce.	1
In industrial areas, sulphur dioxide in industrial emissions kills lichens, which are particularly	2
sensitive to its toxic effects.	1
Also, soot may darken tree trunks.	1
Both cause uniformly dark tree trunks.	1
In this environment, birds prey selectively on "normal" forms,	1
so the melanic forms survive, reproduce, and pass on their melanic genes to the next generation.	1
Since the melanic gene is dominant, it is easily	1
maintained in the area even if migration of moths with "normal" genes occurs from the surrounding country.	1
Possible:	26
Maximum:	20
Quality:	2
Total:	22

DRAFT

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B051KjMA.01
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 51Kj
UNIT NUMBER: 05	INSTRUMENT TYPE: MA
UNIT NAME: THEORY OF EVOLUTION	KLOPFER: A.1, A.2, A.3, A.5
TOPIC: Genetic Variability	DIFFICULTY LEVEL: M
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:

KEYWORDS: isolation genetic drift mutation recombination natural selection

Guideline Objective

Students will be expected to describe three or more of the mechanisms that can lead to genetic variation in a population, e.g. mutation, natural selection, genetic drift, gene flow (migration) and population increase and decrease.

Item Focus

The student should be able to match terms related to genetic variation with the appropriate descriptions.

Item

Select the description from the right column that best matches each of the terms listed in the left column. Enter the number of the appropriate description in the blank to the left of the term.

_____ A. isolation	1.	A source of variation whose importance is greatly enhanced through the occurrence of sexual reproduction in the great majority of plants and animals.
_____ B. genetic drift	2.	A necessary preliminary to the splitting of a freely-interbreeding population into sub-populations whose gene frequencies differ from that of the original one.
_____ C. gene mutation	3.	An evolutionary factor operative in small populations to eliminate some allelic genes through pure chance.
_____ D. genetic recombination	4.	A factor which operates to eliminate individuals that produce fewer offspring than their competitors in a given environment.
_____ E. natural selection	5.	A shift in the gene pool of a population by the emigration of a substantial number of individuals.
	6.	A possible source of variation which, in many cases, may not be evident phenotypically unless present in enough individuals of the population so that it can become homozygous.

Response/Marking Scheme

Correct responses: A-2, B-3, C-6, D-1, E-4

Maximum: 5

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 05
UNIT NAME: THEORY OF EVOLUTION

TOPIC: Natural Selection
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B051KjSA.01
GUIDELINE OBJECTIVE CODE: 51Kj
INSTRUMENT TYPE: SA
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: genetic variability

Guideline Objective

Students will be expected to describe three or more of the mechanisms that can lead to genetic variation in a population, e.g. mutation, natural selection, genetic drift, gene flow (migration) and population increase and decrease.

Item Focus

The student should be able to describe causes of genetic variation.

Item

Name three processes which cause genetic variation and explain how each contributes to natural selection.

Response/Marking Scheme

Any 3 at 3 marks each.

1. mutation: provides a new source of genetic information for the gene pool. This increases the variability of prototypes, which provides more information on which natural selection may act.

2. recombination: This provides new assortments of genetic material. These different groupings may provide a more beneficial combination for the forces of natural selection.

3. random assortment: This contribute new combinations of maternal and paternal chromosomes, creating more variation in the gene pool.

4. sexual reproduction: combination of gametes contributes to the variation in the gene pool.

Possible: 9

Maximum: 9

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B051KjSA.02
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 51Kj
UNIT NUMBER: 05	INSTRUMENT TYPE: SA
UNIT NAME: THEORY OF EVOLUTION	KLOPFER: A.1, A.2, A.3
TOPIC: Isolation	DIFFICULTY LEVEL: M
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:

KEYWORDS: natural selection

Guideline Objective

Students will be expected to describe three or more of the mechanisms that can lead to genetic variation in a population, e.g. mutation, natural selection, genetic drift, gene flow (migration) and population increase and decrease.

Item Focus

The student should be able to list at least three isolating mechanisms and explain why they are necessary for speciation.

Item

Often two different species have arisen from one ancestral species yet both species still occur in the same region. List four isolating mechanisms to account for this situation.

Response/Marking Scheme

Accept any four 4

-different habitats preventing mating
-seasonal fertile periods preventing mating
-ethological differences preventing mating
-mechanical incompatabilities preventing mating
-sterility of the offspring

Maximum: 4

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 05
UNIT NAME: THEORY OF EVOLUTION

TOPIC: Isolation
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B051KjSA.03
GUIDELINE OBJECTIVE CODE: 51Kj
INSTRUMENT TYPE: SA
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: M
TIME ALLOCATION:

KEYWORDS: species natural selection

Guideline Objective

Students will be expected to describe three or more of the mechanisms that can lead to genetic variation in a population, e.g. mutation, natural selection, genetic drift, gene flow (migration) and population increase and decrease.

Item Focus

The student should be able to list at least three isolating mechanisms and explain why they are necessary for speciation.

Item

Mallards and black ducks, two sympatric species, exist in the same habitat. How would each of the following factors contribute to speciation between two such closely related species? Give an example to illustrate each factor.

A. habitat

B. mating behaviour

C. time of maturity

D. reproductive structure

Response/Marking Scheme

A. If two populations exist in the same area, but occupy different niches, it is possible that they may be isolated enough that reproduction may not occur. This would be the result of geographic isolation on a small scale. 2

B. Differences in mating behaviour can actually result in an inability for two different populations to mate. This behavioural difference is enough to assure that each population will maintain its identity. 2

C. If two populations attain maturity at different times of the year, they would then be unable to share gametes, thus they would be unable to produce offspring. 2

D. When two populations have reproductive structures so different that they inhibit mating or fertilization, the populations are again as if they were in isolation, even though they may inhabit the same area. 2

Any suitable example, one for each. 4

Possible: 12

Maximum: 12

Teacher Notes

DRAFT

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B051KjSA.04
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 51Kj
UNIT NUMBER: 05	INSTRUMENT TYPE: SA
UNIT NAME: THEORY OF EVOLUTION	KLOPFER: A.1, A.2, A.3, A.10, D.3
TOPIC: Genetic Basis of Evolution	DIFFICULTY LEVEL: L
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:

KEYWORDS: mutations

Guideline Objective

Students will be expected to describe three or more of the mechanisms that can lead to genetic variation in a population, e.g. mutation, natural selection, genetic drift, gene flow (migration) and population increase and decrease.

Item Focus

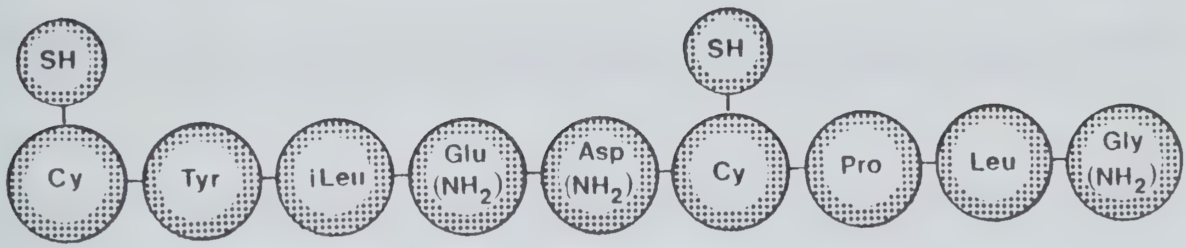
The student should be able to apply knowledge of mutations and DNA triplets to solve a problem in evolution.

Item

Refer to Figure 5K.15.

THE AMINO ACID SEQUENCES OF TWO BEEF HORMONES

OXYTOCIN:



VASOPRESSIN:

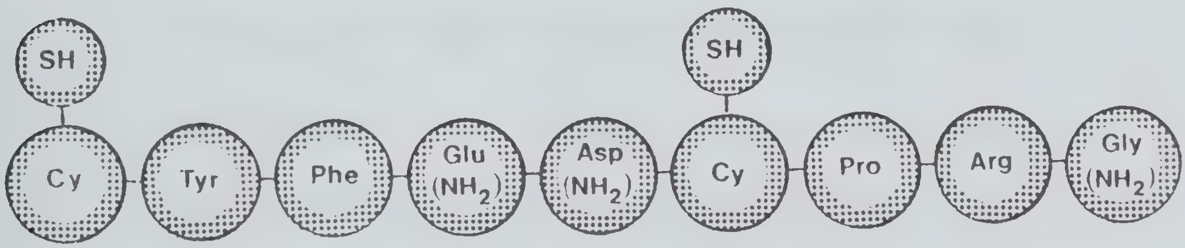


Figure 5K.15 shows the arrangement of amino acids in two beef hormones. What is the minimum number of base substitution mutations that could cause oxytocin to evolve into vasopressin?

Response/Marking Scheme

The minimum number of base substitution mutations is 2. 2

Possible: 2

Maximum: 2

Teacher Notes

DRAFT

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B051KkMC.01
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 51Kk
UNIT NUMBER: 05	INSTRUMENT TYPE: MC
UNIT NAME: THEORY OF EVOLUTION	KLOPFER: A.1, A.2, A.3
	DIFFICULTY LEVEL: M
TOPIC: Genetic Variability	TIME ALLOCATION:
CURRICULAR EMPHASIS: Solid Foundations	

KEYWORDS: sexual reproduction

Guideline Objective

Students will be expected to state the relationship between genetic variation and speciation and postulate how new species can result, for example, through geographical isolation.

Item Focus

The student should be able to identify factors which permit evolution to proceed more rapidly.

Item

Evolution can take place more rapidly among organisms which reproduce sexually because

- ☐ A. asexual reproduction is possible only in single-celled organisms.
- ☐ B. sexual reproduction is more likely to produce a variety of offspring.
- ☐ C. asexual reproduction gives rise to more mutations.
- ☐ D. sexual reproduction is more haxardous than asexual, so that only the fittest survive.
- ☐ E. meiosis takes place only in sexually-reproducing organisms.

Response/Marking Scheme

Correct response: B

Teacher Notes

DRAFT

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 05
UNIT NAME: THEORY OF EVOLUTION

TOPIC: Speciation
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B051KkMC.02
GUIDELINE OBJECTIVE CODE: 51Kk
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: adaptive radiation

Guideline Objective

Students will be expected to state the relationship between genetic variation and speciation and postulate how new species can result, for example, through geographical isolation.

Item Focus

The student should be able to identify concepts involved in the evidence for the theory of evolution.

Item

The concept of adaptive radiation implies that

☐ A. two or more lines of descent have evolved from a common ancestor.

☐ B. humans have descended from the apes.

☐ C. all animal groups arose directly from one ancestral type.

☐ D. all well-adapted forms in evolutionary history have survived.

☐ E. only the fittest species have survived.

Response/Marking Scheme

Correct response: A

Teacher Notes

DRAFT

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B051KkER.01
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 51Kk
UNIT NUMBER: 05	INSTRUMENT TYPE: ER
UNIT NAME: THEORY OF EVOLUTION	KLOPFER: A.1, A.2, A.3, A.8, A.9
	DIFFICULTY LEVEL: H
TOPIC: Speciation	TIME ALLOCATION:
CURRICULAR EMPHASIS: Solid Foundations	

KEYWORDS: mutation natural selection species.

Guideline Objective

Students will be expected to state the relationship between genetic variation and speciation and postulate how new species can result, for example, through geographical isolation.

Item Focus

The student should be able to explain the relationships among mutation, natural selection, and speciation.

Item

> 'Genes mutate, individuals are selected, and species evolve.'
>
> (David Hull)

Explain how the actions occurring at the three levels mentioned in the quotation contribute to evolution.

Response/Marking Scheme

Genes determine the characteristics of individuals and species.	1
Different forms (alleles) of the same gene provide the variety that forms the raw material for evolution.	1
Change begins at the gene level, with mistakes in copying, as the DNA that makes up the genes is replicated.	2
These mutations are random, created by chance.	1
Natural selection works on individuals, rather than on genes or species.	1
Each individual contains an assortment of the pool of genes that makes up a population.	1
The assortment of genes that individuals receive may contribute to making them better adapted to survive in their particular environment, or in a new or changing	1
environment. If the genes are to persist in the population gene pool, individuals must succeed in leaving offspring.	1
Thus the gene pool represents the best adapted individuals in terms of reproductive success.	1
Species are made up of all the populations of similar individuals of common ancestry.	1
Thus species constitute a number of gene pools, each of which contains considerable variety.	1
Because of natural selection and mutation, these gene pools are constantly changing.	1
When the changes become great enough that some of the populations are no longer able to interbreed with others,	1
then new species have evolved.	1
Possible:	15
Maximum:	10
Quality:	2
Total:	12

Teacher Notes

DRAFT

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B051KkER.02
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 51Kk
UNIT NUMBER: 05	INSTRUMENT TYPE: ER
UNIT NAME: THEORY OF EVOLUTION	KLOPFER: A.1, A.2, A.3, A.9
	DIFFICULTY LEVEL: H
TOPIC: Speciation	TIME ALLOCATION:
CURRICULAR EMPHASIS: Solid Foundations	

KEYWORDS: chromosomal changes

Guideline Objective

Students will be expected to state the relationship between genetic variation and speciation and postulate how new species can result, for example, through geographical isolation.

Item Focus

The student should be able to explain the role of chromosomal changes in speciation.

Item

Describe the changes that may occur in the chromosomes of individuals of a species during evolution, and discuss the importance of such changes in speciation.

Response/Marking Scheme

Two types of chromosome changes are involved in speciation. In chromosomal mutations,	1
the actual sequences of genes on chromosomes change	1
by having a piece of a chromosome detached and then	1
reattached to another (or the same chromosome after	1
rotation). Chromosomes may also be	1
duplicated, either singly (heteroploidy), or	1
in entire sets (polyploidy). Both can cause an instant	1
barrier to sexual reproduction	1
between the mutated individual and others of its species.	1
This enables speciation to occur without actual physical separation between the two sub-populations.	1
It is particularly effective in sessile species with	1
the capacity to reproduce asexually, and thereby to	1
build up a sizable population of individuals having	1
the same chromosomal change. Gene flow by sexual means can only occur within this population.	1
Possible:	14
Maximum:	10

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B051KkER.03R
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 51Kk
UNIT NUMBER: 05	INSTRUMENT TYPE: ER
UNIT NAME: THEORY OF EVOLUTION	KLOPFER: A.1, A.2, A.3
	DIFFICULTY LEVEL: H
TOPIC: Speciation	TIME ALLOCATION:
CURRICULAR EMPHASIS: Nature of Science	

KEYWORDS: geographical isolation

Guideline Objective

Students will be expected to state the relationship between genetic variation and speciation and postulate how new species can result, for example, through geographical isolation.

Item Focus

The student should be able to explain the influence of geographical barriers on the development and distribution of life forms.

Item

Refer to Figure 5K.16.

LIFE REALMS OF OUR PLANET

On the basis of similarities and differences among the organisms that occur in different parts of the world, the continents and islands have been classified into five major life realms, as shown in Figure 5K.16.

A. What features of the geography of our planet have led to the development of different life realms? How did geography influence evolution?

B. In each of the life realms, grasslands have developed, with typical grazing mammals and their predators. How did grassland biomes develop on different continents, each with its typical large grazing mammals?

C. Alfred Russel Wallace described the difference in the animal life of the Oriental and Australian realms. He inferred that there must be an isolating mechanism between the

realms. The barrier separating the realms has been call "Wallace's Line". Wallace's Line separates the islands of Bali and Lombok, only 30 km apart. What would you expect to observe about the nature of the strait between these islands.

D. Ernst Mayr has pointed out that the barrier between Bali and Lombok is just one of many borderlines between islands, where the animals of the Oriental and Australian realms gradually merge. He published the following data for the efficiency of each of the barriers in stopping the spread of species of birds:

Which strait forms the most effective barrier?

ISLANDS	BALI	LOMBOK	ALAS	SAPE	FLORES	KAMBING
AUSTRALIAN SPECIES STOPPED	3	15	12	8	4	0
ORIENTAL SPECIES STOPPED	?	68	10	7	24	13

Response/Marking Scheme

A. Geography describes the physical features of the planet, which include barriers that restrict the movement of organisms, such as mountain ranges and oceans, deserts and ice fields. 2

Such barriers prevent gene pools from mixing. 1

Separate gene pools contribute to evolution by accumulating mutations until interbreeding is not 1

possible, creating new species. 1

B. Grasses are particularly hardy species, whose seeds are readily spread, and which can survive when rainfall is not adequate to support the growth of trees. 2

Grasslands also withstand fire better than forests. 1

Possibly the ancestors of the grasses spread to all continents when the continents were joined into one land mass. 1

Since the continents have been separate, the grasses have differentiated, forming characteristic species. 1

The grazing mammals are similar in four of the realms; perhaps their common ancestor spread while the land masses were joined. 1

Australia has been separated from the other continents longest; its grazing mammals are marsupials (kangaroos) rather than placental mammals such as the bovids (beef family) and the camelids. 1

Large mammals escape predation more successfully, but require more resources. A large grassland is needed to fix enough energy to support large herbivores. 1

C. Wallace's line between the islands of Bali/Lombok likely runs through water that forms a difficult barrier for land organisms. 1

(Accept any reasonable speculation) Strong winds may deter birds from crossing. OR There may be a strong current, or particularly rough waves, or perhaps a cold current to make unlikely the passage of any swimmers. 2

D. The Bali/Lombok strait. 1

Possible: 17

Maximum: 12

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 05
UNIT NAME: THEORY OF EVOLUTION

TOPIC: Speciation
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B051KkER.04
GUIDELINE OBJECTIVE CODE: 51Kk
INSTRUMENT TYPE: ER
KLOPFER: A.1, A.2, A.3, A.9
DIFFICULTY LEVEL: M
TIME ALLOCATION:

KEYWORDS: isolating mechanisms

Guideline Objective

Students will be expected to state the relationship between genetic variation and speciation and postulate how new species can result, for example, through geographical isolation.

Item Focus

Same as above

Item

Using at least five isolating mechanisms, explain how speciation can occur.

Response/Marking Scheme

Speciation, the formation of new species, may occur when two or more populations of a parent species become separated so that their gene pools are not in active interchange. 2

Five mechanisms that can cause such reproductive isolation are:

1. geological barriers that prevent members of two 1
   populations from mating, for example, a wide expanse of ocean between islands. 1
2. adaptation to different ecological conditions, 1
   for example, one population may live on higher, drier mountains than another, and may not seek out mates from a population living in deep moist valleys. 1
3. behavioural isolation may result when members of one 1
   population do not send out a response to specific behavioural signals of another population. 1
4. morphological differences may prevent matings between different variants of the same species. 1
   For example, in mayfly populations, the structure of the reproductive apparatus prevents certain populations from mating with others. 1
5. genetic incompatibility may arise to prevent the successful mating of two members of different populations. 1
   For example, sperms from one population of frogs may be unable to fertilize the eggs of a different population. 1
   (other acceptible mechanisms are temporal variations in breeding cycle, hybrid inviability, and hybrid sterility.)

Possible: 12

Maximum: 10

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B051KkLA.01
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 51Kk
UNIT NUMBER: 05	INSTRUMENT TYPE: LA
UNIT NAME: THEORY OF EVOLUTION	KLOPFER: A.1, A.2, A.3, A.4, A.5, A.7, A.9, C.1, C.2, C.3, D.3
TOPIC: Genetic Variability	DIFFICULTY LEVEL: H
CURRICULAR EMPHASIS: Nature of Science	TIME ALLOCATION:

KEYWORDS: natural selection Kettlewell gene frequencies

Guideline Objective

Students will be expected to state the relationship between genetic variation and speciation and postulate how new species can result, for example, through geographical isolation.

Item Focus

The student should be able to interpret the results of Kettlewell's experiments on natural selection of the peppered moth.

Item

In the 1950's, Kettlewell performed an experiment on the peppered moth, *Biston betularia*, whereby the black (dominant) and the white (recessive) varieties of the moth were released into an industrialized area (where the trees had lost their lichen cover and were black in colour) and into a rural area (with plenty of light-coloured lichen coating the bark of the trees). After a period of time, moths were recaptured from these areas. The following table contains the results of this work.

Kettlewell's Observations

UNPOLLUTED AREA		POLLUTED AREA	
Light moths		Light moths	
released	496	released	137
recaptured	62	recaptured	18
Dark moths		Dark moths	
released	473	released	447
recaptured	30	recaptured	123

A. Name and state the principle of biology that is demonstrated by Kettlewell's results.

B. Using the data supplied, calculate the frequency changes in each situation in terms of the population of moths released and recaptured.

C. Explain the events occuring in this experiment.

D. Criticize the experiment on the basis of the numbers released and the efficiency of the birds as predators in both environments.

E. When air pollution was reduced in the 1970's, lichens began to grow on the trees of the industrialized area. The frequency of white moths in the area again increased to the disadvantage of the black ones. From where did these white moths come?

Response/Marking Scheme

A. natural selection-the mechanism for the change of frequency of alleles that leads to evolutionary change. 2

B. Unpolluted area

- the white moths increased from a frequency of 0.51 to 0.67 1
- the black moths decreased from a frequency of 0.49 to 0.33 1

Polluted area

- the white moths decreased from a frequency of 0.23 to 0.12 1
- the black moths increased from a frequency of 0.77 to 0.87 1

C. Within the total population, there exists alleles for a variation of colour (black and white). 1

Since the moth is a diploid individual, one of the two alleles could be recessive and can be masked by the dominant allele in the heterozygous state. 1

In the unpolluted area, since the white moths blend with the lichen covering on the trees, they will less likely 2

be captured by predators than the black moths which are conspicuous. 1

Therefore, the black moths will decrease in frequency 1

and the white moths will increase in frequency. Since the black allele is dominant, this allele is not hidden by the white allele and therefore, is more susceptible to a decrease in frequencly when being selected against. 1

In the polluted area, the opposite occurs. 1

D. The number of light moths released in the polluted forest was only about one-quarter of the numbers of others released. 1

This introduces a methodological bias into the experiment. 1

In the two environments, different birds may be serving as the predators with possible differences in 1

in the efficiency of predation. 1

The population frequency changes, however, appear to be statistically valid 1

and the control in each environment would eliminate the effect of differences in predation efficiency. 1

E. At no time in this experiment did the alleles that produce white colour disappear from the population. There are some alleles for white hidden in the heterozygous condition 1 1

because these organisms are diploid, so the allele is never totally selected against as in haploid organisms. Consequently, when the environmental background changed from a polluted one to an unpolluted one, the frequency of white moths increased. 1

Possible: 21

Maximum: 15

Quality: 3

Total: 18

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 05
UNIT NAME: THEORY OF EVOLUTION

TOPIC: Genetic Variability
CURRICULAR EMPHASIS: Nature of Science

INSTRUMENT CODE: B051KkLP.01
GUIDELINE OBJECTIVE CODE: 51Kk
INSTRUMENT TYPE: LP
KLOPFER: A.1, A.2, A.3, A.4, A.5, A.7, A.9, C.1, C.2, C.3, D.3
DIFFICULTY LEVEL: H
TIME ALLOCATION:

KEYWORDS: mutation artificial selection gene frequencies

Guideline Objective

Students will be expected to state the relationship between genetic variation and speciation and postulate how new species can result, for example, through geographical isolation.

Item Focus

The student should be able to design an experiment to illustrate selection as a mechanism of evolution.

Item

You have been asked to develop a population of bacteria having a tolerance to a higher than normal saline condition.

A. Beginning with a single species of such organisms, how would you accomplish this task?

B. How does the technique you selected enable you to change the frequency of the tolerance gene?

Response/Marking Scheme

A. Plate the population on several concentrations of 1
hypersaline media. Select the bacteria colonies that tolerate the highest concentration of salt. 1

B. This is a simple experiment using artifical selection. Within any population of bacteria, there is variation, 2
the result of many mutations. It is probable that some mutant alleles allow for a greater tolerance of an osmotically active environment. 1
But in a normal environment, these would have no selective value. 1
Since bacteria are haploid, the presence of alleles would soon be apparent in the hypersaline environment. 1
Increasing the salt concentration of the media would select against those organisms that are sensitive to the 1
high salt concentration: those that do not have the 1
tolerant allele would die. Only those with the saline tolerance would survive, reproducing asexually, creating a colony of saline-tolerant individuals. 1
This is a very fast way to influence evolution. The frequency of the saline tolerance gene would go from a value close to 0 to a frequency of 1 in one generation. 1

Possible: 10

Maximum: 8

Teacher Notes

DRAFT

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 05
UNIT NAME: THEORY OF EVOLUTION

TOPIC: Speciation
CURRICULAR EMPHASIS: Nature of Science

INSTRUMENT CODE: B051KkSA.01
GUIDELINE OBJECTIVE CODE: 51Kk
INSTRUMENT TYPE: SA
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: H
TIME ALLOCATION:

KEYWORDS: species natural selection isolation

Guideline Objective

Students will be expected to state the relationship between genetic variation and speciation and postulate how new species can result, for example, through geographical isolation.

Item Focus

The student should be able to list at least three isolating mechanisms and explain why they are necessary for speciation.

Item

Refer to Figure 5K.17.

RANGES OF SUBSPECIES OF THE SONG SPARROW

Figure 5K.17 is a map showing a number of subspecies of song sparrows in North America.

A. What is the significance of the presence of these subspecies?

B. Explain the most common way such subspecies arise.

C. If the conditions which caused the subspecies to appear maintain themselves, what may be the outcome?

Response/Marking Scheme

A. The significance of these subspecies is that the original population from which these subspecies originated must have undergone adaptive radiation of some members of the original population. 1

These portions of the population, through natural selection, were more adapted to these new habitats. 1

B. The development of the subspecies often follows these steps:

1. There is a large variety of genes in the original pool subject to natural selection. 1
2. Some individuals become separated through natural migration 1
   to habitats that are slightly different from the original population's habitat. 1
3. If these conditions are maintained, the subspecies 1
   will continue to breed among themselves, enhancing 1
   those traits which made them more suited to this new habitat. 1

C. If the subspecies remain separated from the original population, in time, it undergoes genetic drift. 1

If this occurs to a significant degree, the 1

subspecies become reproductively isolated from one another. 1

Then they are no longer considered subspecies, but distinct species. 1

Possible: 12

Maximum: 10

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 05
UNIT NAME: THEORY OF EVOLUTION

TOPIC: Speciation
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B051KlMC.01
GUIDELINE OBJECTIVE CODE: 51Kl
INSTRUMENT TYPE: MC
KLOPFER: A.9
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: genetic variability isolation

Guideline Objective

Students will be expected to describe the possible origin of Darwin's finches, or some other groups of related species, in terms of initially reduced selection pressure, increased genetic variation, isolation, reuniting of species, competition and increased selection pressure.

Item Focus

The student should be able to identify aspects of the explanation of speciation.

Item

Which one of the following is **NOT** involved in speciation?

☐ A. variability in the environment.

☐ B. a homogeneous environment.

☐ C. geographical isolation.

☐ D. gamete incompatibility.

☐ E. different breeding seasons.

Response/Marking Scheme

Correct response: B

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 05
UNIT NAME: THEORY OF EVOLUTION

TOPIC: Speciation
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B051KlER.01
GUIDELINE OBJECTIVE CODE: 51Kl
INSTRUMENT TYPE: ER
KLOPFER: A.1, A.2, A.3, A.5.
DIFFICULTY LEVEL: M
TIME ALLOCATION:

KEYWORDS: Darwin Galapagos Islands

Guideline Objective

Students will be expected to describe the possible origin of Darwin's finches, or some other groups of related species, in terms of initially reduced selection pressure, increased genetic variation, isolation, reuniting of species, competition and increased selection pressure.

Item Focus

The student should be able to explain how speciation may have produced the different finches in the Galapagos islands.

Item

As a group, finches are recognized as birds with stout bills adapted for cracking seeds. On the Galapagos Islands, about 1000 km from South America, the nearest land, Darwin found a remarkable group of finches. They were very similar in appearance except for their bills, which were adapted for securing food from many different niches.

A. How might finches first have reached the Galapagos?

B. Explain how new species might have arisen from a common ancestral group.

C. How might the geography of oceanic islands have contributed to speciation?

Response/Marking Scheme

A. During migration, birds fly long distances, so it is possible for a flock to fly 1000 km, although it is unusual. Perhaps a strong wind blew them off course. 2

B. Once the finches scattered to several islands, their gene pools would become isolated, since the islands are separated by large distances of open water. Land birds would not normally go so far to seek mates. 2

In smaller gene pools, mutations would more easily become established, changing the population more quickly than in larger populations. 2

Natural selection would favour successful adaptations, enabling the surival of birds that could fit niches where food was available, and fostering their 2

reproduction.

C. The water between islands formed a natural barrier to land-based birds, keeping their gene pools apart. 2

Possible: 10

Maximum: 8

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B051KlER.02
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 51Kl
UNIT NUMBER: 05	INSTRUMENT TYPE: ER
UNIT NAME: THEORY OF EVOLUTION	KLOPFER: A.1, A.2, A.3, A.5, A.8 - 10, D.3, E.5
TOPIC: Speciation	DIFFICULTY LEVEL: H
CURRICULAR EMPHASIS: Nature of Science	TIME ALLOCATION:

KEYWORDS: natural selection adaptation

Guideline Objective

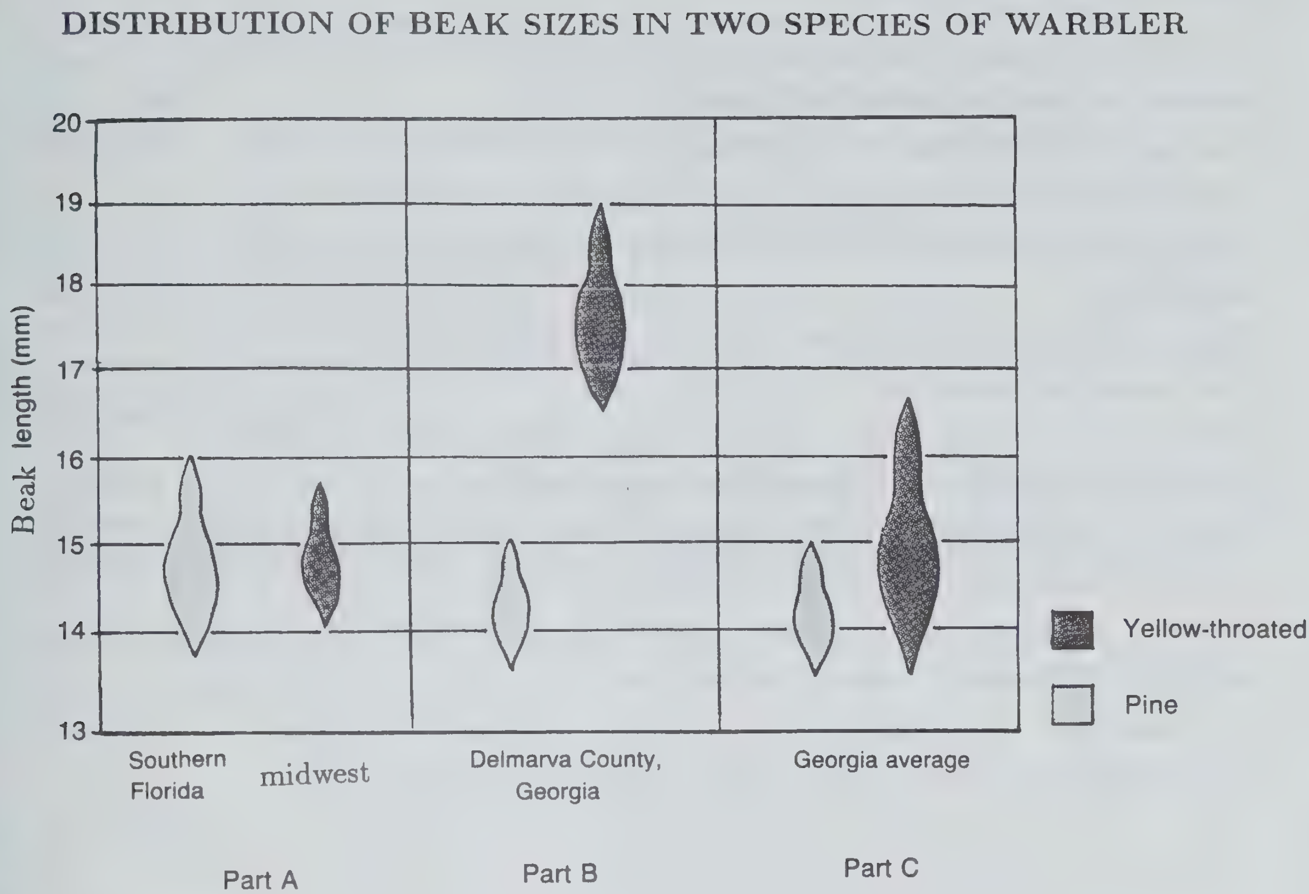
Students will be expected to describe the possible origin of Darwin's finches, or some other groups of related species, in terms of initially reduced selection pressure, increased genetic variation, isolation, reuniting of species, competition and increased selection pressure.

Item Focus

The student should be able to apply knowledge of Darwin's finches to the warblers of Georgia.

Item

Refer to Figure 5K.18.



The graph in Figure 5K.18 compares the distribution of beak sizes in the populations of two species of warbler, the pine warbler (*Dendroica pinus*), an eastern species, and the yellow-throated warbler, (*Dendroica dominica*), basically a western bird, from different geographical regions of the United States.

In part A, the beaks of pine warblers were measured for a Florida population, and the yellow-throated for a population in the midwest. In part B, the beak lengths were measured for two populations in the same county of Georgia, where the ranges of the two birds overlap. Data in part C were obtained by averaging data for the populations of the two species over the whole of Georgia.

Use evolutionary theory to account for the differences in the distributions of beak lengths in the three situations.

Response/Marking Scheme

Since both bird species are warblers of the same genus, they are likely to compete for resources such as food (insects).	1
The major use of the beak is for obtaining food.	1
In areas where the two species are not in contact, such as Florida and the midwest (Part A), the two species have similar beak sizes, and likely exploit similar food.	1
When the two species live together (Part B), natural selection has not favoured either species in competition	1
with the other. Instead, there has been selection in favour of individuals with beak lengths that differ from those of the other species.	1
Thus after many generations of such selection, beak lengths have diverged, and the two species experience little competition.	1
In Part C, when the samples are drawn from a larger area, instead of the same county, the separation of ranges is less complete,	1
thus competition is less severe,	1
and natural selection has not eliminated individuals as stringently.	1
Possible:	9
Maximum:	6

Teacher Notes

DRAFT

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B051KlER.03
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 51Kl
UNIT NUMBER: 05	INSTRUMENT TYPE: ER
UNIT NAME: THEORY OF EVOLUTION	KLOPFER: A.1, A.2, A.3, A.8, I.3
	DIFFICULTY LEVEL: H
TOPIC: Speciation	TIME ALLOCATION:
CURRICULAR EMPHASIS: Nature of Science	

KEYWORDS: Darwin natural selection

Guideline Objective

Students will be expected to describe the possible origin of Darwin's finches, or some other groups of related species, in terms of initially reduced selection pressure, increased genetic variation, isolation, reuniting of species, competition and increased selection pressure.

Item Focus

Same as above.

Item

Refer to Figure 5K.19.

THE BEAKS OF SOME OF DARWIN'S FINCHES

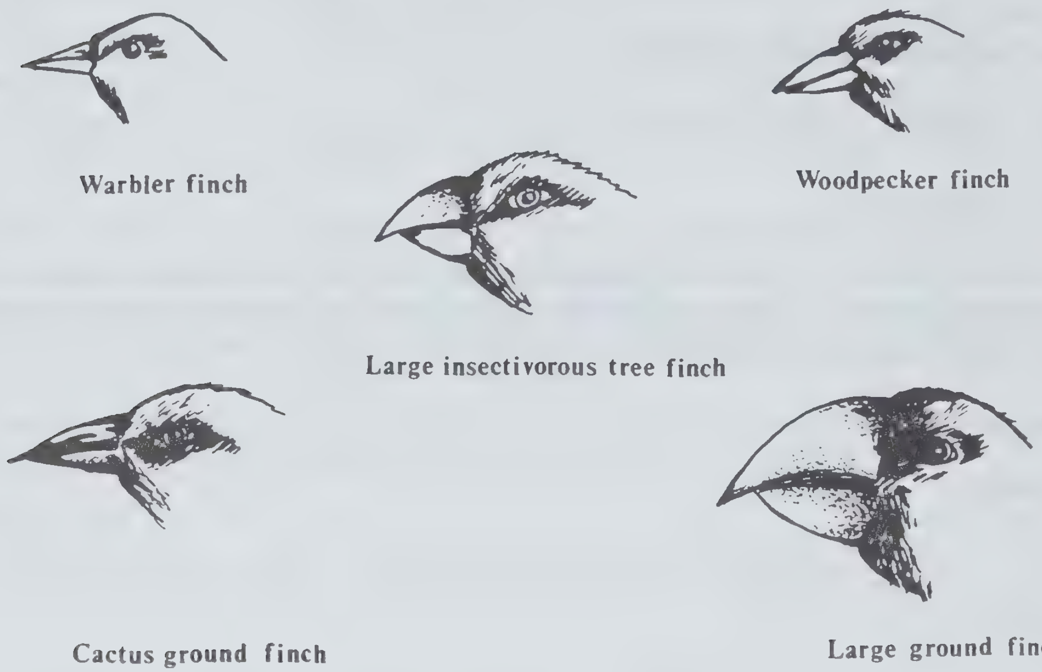


Figure 5K.19 shows the heads and beaks of some of the fourteen species of finches Darwin found on the Galapagos Islands. In his *Journal of Researches. . .*, Darwin wrote:

> "Seeing this gradation and diversity in one small, intimately related group of birds, one might really fancy that from an original paucity (scarcity) of birds in this archipelago, one species had been taken and modified for different ends."

A. What do the beaks of members of the finch family have in common? Discuss the adaptations of the structure of these beaks to their functions.

B. How could one species have been "taken and modified for different ends?" Discuss this process with reference to the Galapagos Islands.

C. The "woodpecker" finch is very unlikely to have devised its tool-using strategy by reasoning. By what small steps could such a strategy have been rewarding enough to develop the full skill of being able to break off a cactus thorn and use it to probe holes in the bark in search of food?

Response/Marking Scheme

A. Finches are characterized by stout, curved beaks that are able to pull seeds out of fruit and crack them open. 3

B. When the first flock of finches arrived on the islands, many feeding niches must have been vacant. 2

The flock separated into populations in each of the niches, and on each of the islands. As time went on, 2

each separate flock developed phenotypes for more efficient food-gathering. Some of these changes were inherited. 2

Some may have formed barriers 1

against interbreeding with other flocks. 1

In time each separate flock developed its own unique gene pool, becoming a separate species. 2

C. Accept any suitable hypothesis, such as 3

1. Finch locates insect on a thorn;

2. Finch breaks thorn and discovers insect.

3. Finch breaks thorn, spots grub in hole.

4. Finch breaks thorn, accidentally pokes hole, disturbing as grub which emerges.

5. Finch breaks thorn, pokes hole, and is rewarded by spearing a grub on the thorn.

6. Other finches of the same species see this behaviour and learn.

Possible: 16

Maximum: 12

Teacher Notes

DRAFT

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B051KlER.04
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 51Kl
UNIT NUMBER: 05	INSTRUMENT TYPE: ER
UNIT NAME: THEORY OF EVOLUTION	KLOPFER: A.1, A.2, A.3, A.8, A.9, C.2, F.1
TOPIC: Speciation	DIFFICULTY LEVEL: M
CURRICULAR EMPHASIS: Nature of Science	TIME ALLOCATION:

KEYWORDS: natural selection

Guideline Objective

Students will be expected to describe the possible origin of Darwin's finches, or some other groups of related species, in terms of initially reduced selection pressure, increased genetic variation, isolation, reuniting of species, competition and increased selection pressure.

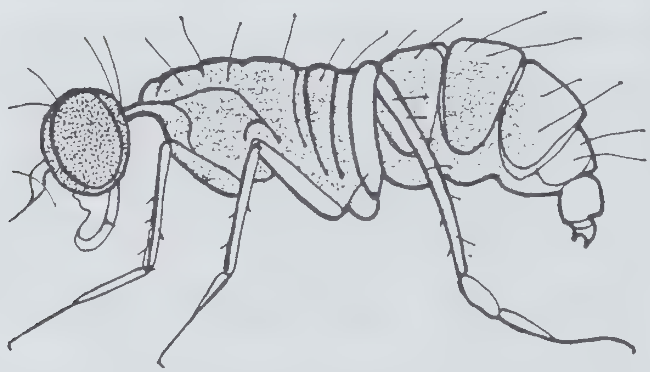
Item Focus

The student should be able to apply the concepts of mutation and selection pressure to explain the likely origin of a population of wingless flies.

Item

Refer to Figure 5K.20.

A FLY FROM A TINY PACIFIC ISLAND



x 15

Figure 5K.20 is a drawing of a species of fly, *Acropsilus borboroides*. It occurs only on Campbell Island, a tiny island near New Zealand.

A. What single trait of this fly is most unlike all other true flies ?

B. Give a reasonable evolutionary explanation to account for the unusual feature.

Response/Marking Scheme

A. It has no wings.	1
B. Accept any reasonable hypothesis such as: Many generations ago, ancestors of this fly had wings, when they arrived on Campbell Island.	1
Natural selection has worked on each generation of flies.	1
Apparently, being able to fly reduced the flies' chances of survival,	1
perhaps because flying insects could easily be blown out to sea,	1
or because flight requires more energy, and non-flying individuals could maintain themselves better with less energy.	1
At the same time, the ability to fly became less important than it had been to the ancestors,	1
perhaps because there were no predators to escape	1
from or because the island was small enough that the species could disperse and find mates without flying.	1
Hence, after many generations in which non-flying individuals generated more offspring than flying individuals, the species became flightless.	1
Possible:	10
Maximum:	6

Teacher Notes

DRAFT

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B051KlSA.01
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 51Kl
UNIT NUMBER: 05	INSTRUMENT TYPE: SA
UNIT NAME: THEORY OF EVOLUTION	KLOPFER: A.1, A.2, A.3, A.8, I.3
	DIFFICULTY LEVEL: M
TOPIC: Speciation	TIME ALLOCATION:
CURRICULAR EMPHASIS: Nature of Science	

KEYWORDS: Darwin Galapagos Islands geographical isolation

Guideline Objective

Students will be expected to describe the possible origin of Darwin's finches, or some other groups of related species, in terms of initially reduced selection pressure, increased genetic variation, isolation, reuniting of species, competition and increased selection pressure.

Item Focus

The student should be able to discuss geographical isolation with regard to speciation among plants.

Item

Charles Darwin wrote of the plants of the Galapagos Islands in his *Journal of Researches into the Natural History and Geology of the countries visited during the Voyage of H. M. S. Beagle Round the World. . .*

> "The botany of this group (of islands) is fully as interesting as the zoology. . . . Of flowering plants there are, as far as at present is known, 185 species. . . . 100 are new species, and are probably confined to this archipelago."

Here is Dr. Joseph Hooker's analysis of the plants of the legume family that Darwin collected on islands of the Galapagos:

ISLAND	TOTAL NUMBER OF SPECIES	NUMBER FOUND ELSEWHERE IN THE WORLD	NUMBER FOUND ONLY IN THE GALAPAGOS	NUMBER FOUND ON ONLY ONE ISLAND
SAN SALVADOR	71	33	38	30
ISABELA	44	78	26	22
SAN CRISTOBAL	32	16	16	12
SANTA MARIA	68	39	29	21

A. Geologically, the Galapagos islands are thought to be of relatively recent origin, since they are volcanoes thrust up from the deep sea floor, and have never been part of any continental land mass. Suggest three hypotheses to explain how plants of the legume family might have arrived at the Galapagos.

B. Explain how so many new species of legumes might have arisen on the Galapagos Islands.

Response/Marking Scheme

A. Any three reasonable hypotheses, such as the following, which Darwin tested experimentally, (Maximum 3 each) 9

1. The seeds might float, and might be carried by ocean currents, and then washed ashore by waves.

2. The seeds might have been eaten by birds, but not digested; The birds might have flown to the Galapagos. The seeds might have been ejected with fecal matter.

3. The seeds might have been eaten by birds, but not swallowed, kept in the crop. The bird may have died and floated on ocean currents until washing ashore.

OR The seeds or dried plants with fruits might have been washed from the beaches of South America and carried as rafts of floating debris by ocean currents then washed them ashore by wave action.

OR Fish might have swallowed floating seeds, and carried them to the Galapagos, where seals may have eaten the fish and excreted the seeds.

OR Seeds might be carried stuck in mud on the feet of ducks.

B. Founder populations must have been very small 1

thus the gene pool would not have closely resembled that of its parent population. 1

In isolation, any mutations would have had a large effect on the gene pool. The accumulation of new 1

alleles would have resulted in new species. 1

Possible: 13

Maximum: 10

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B051KlSA.02
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 51Kl
UNIT NUMBER: 05	INSTRUMENT TYPE: SA
UNIT NAME: THEORY OF EVOLUTION	KLOPFER: A.1, A.2, A.3, A.9, I.3
	DIFFICULTY LEVEL: L
TOPIC: Speciation	TIME ALLOCATION:
CURRICULAR EMPHASIS: Nature of Science	

KEYWORDS: Darwin finches Galapagos Islands

Guideline Objective

Students will be expected to describe the possible origin of Darwin's finches, or some other groups of related species, in terms of initially reduced selection pressure, increased genetic variation, isolation, reuniting of species, competition and increased selection pressure.

Item Focus

The student should be able to identify the observation that stimulated Darwin's thinking about speciation.

Item

Consider the evidence and tentative inference that Darwin wrote about the finches of the Galapagos Islands:

> "The remaining land-birds form a most singular group of finches, related to each other in the structure of their beaks, short tails, form of body and plumage: there are thirteen species . . . divided into four sub-groups. . Of *Cactornis* [cactus ground finch], the two species may often be seen climbing about the flowers of the great cactus-trees;. . . The males . . .are jet black; and the females . . . are brown. The most curious fact is the perfect gradation in the size of the beaks of *Geospiza* [ground finches], from one as large as that of a hawfinch to . . . that of a warbler. . . . there are no less than six species with insensibly graduated beaks. . . . The beak of *Cactornis* is somewhat like that of a starling; and that of the fourth sub-group, *Camarhynchus* [tree finches], is slightly parrot shaped."

What was it about the Galapagos finches that started Darwin thinking about speciation?

Response/Marking Scheme

Although different species, the birds looked enough alike to have become modified during descent from a common ancestor. 2

Possible: 2

Maximum: 2

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B051KlSA.03
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 51Kl
UNIT NUMBER: 05	INSTRUMENT TYPE: SA
UNIT NAME: THEORY OF EVOLUTION	KLOPFER: A.1, A.3, A.9, I.3
	DIFFICULTY LEVEL: H
TOPIC: Speciation	TIME ALLOCATION:
CURRICULAR EMPHASIS: Nature of Science	

KEYWORDS: Darwin finches Galapagos

Guideline Objective

Students will be expected to describe the possible origin of Darwin's finches, or some other groups of related species, in terms of initially reduced selection pressure, increased genetic variation, isolation, reuniting of species, competition and increased selection pressure.

Item Focus

The student should be able to identify the steps in explaining speciation among the finches of the Galapagos.

Item

Consider the evidence and tentative inference that Darwin wrote about the finches of the Galapagos Islands:

> "The remaining land-birds form a most singular group of finches, related to each other in the structure of their beaks, short tails, form of body and plumage: there are thirteen species . . . divided into four sub-groups. All these species are peculiar to this archipelago and so is the whole group. . . . Of *Cactornis* (ground finch), the two species may often be seen climbing about the flowers of the great cactus-trees; but all the other species of this group of finches, mingled together in flocks, feed on the dry and sterile ground of the lower districts. The males . . . are jet black; and the females . . . are brown. The most curious fact is the perfect gradation in the size of the beaks of *Geospiza* (ground finches), from one as large as that of a hawfinch to . . . that of a warbler. . . . there are no less than six species with insensibly graduated beaks. . . . The beak of *Cactornis* is somewhat like that of a starling; and that of the fourth sub-group, *Camarhynchus* (tree finches), is slightly parrot shaped."
>
> "Seeing this gradation and diversity in one small, intimately related group of birds, one might really fancy that from an original paucity (scarcity) of birds in this archipelago, one species had been taken and modified for different ends."

In explaining speciation in Darwin's finches, which of the following statements would apply, and in what order?

I Over many generations, the birds whose beaks were most successful in obtaining food in different niches were more successful in raising offspring.

II The islands are separated from one another by as much as 30 km of open ocean. This barrier prevented interbreeding and developed separate gene pools on each island.

III Because there were no other birds occupying the different feeding niches, the finches could move into new ways of feeding without competition, and survive, although inefficient.

IV Finches that wanted to crack large cactus seeds developed stout strong beaks, and passed these traits along to their offspring.

V Over time, enough mutations may have accumulated in the gene pools of some populations that they would have been unable to interbreed with birds of other populations.

VI A storm may have blown the original flock of finches from mainland South America to the Galapagos Islands.

Response/Marking Scheme

One mark for each correct statement selected	5
Correct sequence : VI, III, I, II, V	1
Maximum:	6

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B051KmMC.01
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 51Km
UNIT NUMBER: 05	INSTRUMENT TYPE: MC
UNIT NAME: THEORY OF EVOLUTION	KLOPFER: A.1, A.2, A.3, C.2
	DIFFICULTY LEVEL: L
TOPIC: Convergent Evolution	TIME ALLOCATION:
CURRICULAR EMPHASIS: Solid Foundations	

KEYWORDS: species

Guideline Objective

Students will be expected to compare speciation with convergent evolution.

Item Focus

The student should be able to recognize convergent evolution.

Item

Two species of organisms both adapted to the same aquatic environment and living in the same area, resemble each other very closely. From the fossil record, they are known to have evolved from two different terrestrial ancestral stocks. These species

☐ A. are ecological equivalents.

☐ B. have undergone convergent evolution.

☐ C. exhibit serial homology.

☐ D. are phenotypically identical in every respect.

☐ E. are capable of mating together to produce fertile offspring.

Response/Marking Scheme

Correct response: B

Teacher Notes

DRAFT

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B051KmER.01
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 51Km
UNIT NUMBER: 05	INSTRUMENT TYPE: ER
UNIT NAME: THEORY OF EVOLUTION	KLOPFER: A.1, A.2, A.3, A.9, C.2, I.3
	DIFFICULTY LEVEL: M
TOPIC: Convergent Evolution	TIME ALLOCATION:
CURRICULAR EMPHASIS: Nature of Science	

KEYWORDS: species Darwin

Guideline Objective

Students will be expected to compare speciation with convergent evolution.

Item Focus

The student should be able to recognize the mechanics of evolutionary adaptation.

Item

> "Now, as Darwin gazed across the lush, endless-seeming, rolling grassland of the strange continent of South America, a question was forming in his mind. He knew that there was something askew, something not quite right. What was it? Why was he troubled? There was certainly no apparent reason to feel uneasy. The warm breeze gently smoothed the unkept grass, the sky was clear and blue, and his confidence and physical strength were high. But he sensed that in the panorama that unfolded before him something was wrong. Then it came.
>
> There were no rabbits..."
>
> "Where rabbits should have been there were some strange little animals that hopped across the trail from time to time. They had long legs like rabbits and large ears and did many things that rabbits did, but they were clearly not rabbits. They looked more like guinea pigs." They were actually rodents.

The preceeding passage taken from *Biology: The Science of Life*by Wallace, King and Saunders, 1981, illustrates a fundamental evolutionary premise.

A. What is this premise?

B. The answer to Darwin's puzzle helps to explain an evolutionary mechanism. Explain the mechanism by which this rabbit-like rodent evolved. Name and define the process involved.

Response/Marking Scheme

A. Individual species of organisms evolved only once and then migrated to other areas if given the opportunity. 2

B. There were no rabbits in South America because they were unable to migrate from where they evolved to South America. 1

Land bridges did not exist at the time in the evolutionary past when rabbits could have migrated into South America. 2

An ancestor of the rabbit-like rodent, therefore, adapted to the niche that would have otherwise have been occupied by rabbits. 2

This shaping to similar adaptations, by natural selection, of organisms with different ancestry is called convergent evolution. 2

Possible: 9

Maximum: 6

Teacher Notes

Quotation used by permission.

DRAFT

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B051KmER.02
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 51Km
UNIT NUMBER: 05	INSTRUMENT TYPE: ER
UNIT NAME: THEORY OF EVOLUTION	KLOPFER: A.1, A.2, A.3, A.9
	DIFFICULTY LEVEL: H
TOPIC: Convergent Evolution	TIME ALLOCATION:
CURRICULAR EMPHASIS: Solid Foundations	

KEYWORDS: speciation fossil record

Guideline Objective

Students will be expected to compare speciation with convergent evolution.

Item Focus

Same as above.

Item

Two similar species can appear in the fossil record either as a result of divergence from a common ancestor, or as a result of convergent evolution. Explain.

Response/Marking Scheme

The fossils of many species reveal only the external morphology of the species.	1
If a reproductive barrier had recently evolved in two	1
subgroups of a species, it could involve only subtle biochemical or physiological	
features that would not	1
fossilize. The two species would seem similar or identical	2
until sufficient time had passed for morphological changes	1
capable of being preserved as fossils had an opportunity	1
to evolve. The environment selects the same structural and	1
physiological features from unrelated organisms,	2
making them appear more similar	1
in external morphology such as body shape, body covering,	2
and relative proportions of body parts.	1
Possible:	14
Maximum:	10
Quality:	2
Total:	12

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 05
UNIT NAME: THEORY OF EVOLUTION

TOPIC: Speciation
CURRICULAR EMPHASIS: Nature of Science

INSTRUMENT CODE: B051KmER.04
GUIDELINE OBJECTIVE CODE: 51Km
INSTRUMENT TYPE: ER
KLOPFER: A.1, A.2, A.3, A.9, C.2, I.3
DIFFICULTY LEVEL: M
TIME ALLOCATION:

KEYWORDS: adaptation convergent evolution

Guideline Objective

Students will be expected to compare speciation with convergent evolution.

Item Focus

The student should be able to explain the mechanics by which adaptation occurs.

Item

> "Now, as Darwin gazed across the lush, endless-seeming, rolling grassland of the strange continent of South America, a question was forming in his mind. He knew that there was something askew, something not quite right. What was it? Why was he troubled? There was certainly no apparent reason to feel uneasy. The warm breeze gently smoothed the unkept grass, the sky was clear and blue, and his confidence and physical strength were high. But he sensed that in the panorama that unfolded before him something was wrong. Then it came.
>
> There were no rabbits..."
>
> "Where rabbits should have been there were some strange little animals that hopped across the trail from time to time. They had long legs like rabbits and large ears and did many things that rabbits did, but they were clearly not rabbits. They looked more like guinea pigs." They were actually rodents.

What does the preceeding passage taken from *Biology: The Science of Life*by Wallace, King and Saunders, 1981, illustrate with respect to the mechanics of adaptation?

Response/Marking Scheme

A niche normally occupied by rabbits in other parts of the world was left vacant.	1
There was considerable genetic heterozygosity among the ancestral rodent population.	1
This resulted in potential variation in anatomical structure.	1
The separation of a segment of the population resulted in a founding population having a specific survival value in a grassland environment.	1
After many generations, this population became reproductively isolated from the original population.	1
There would be changes over time in the phenotypes of	1
these organisms because of environmental pressures on the genetic variability	1
and a changing genetic variation would result in a	1
phenotypic appearance similar to a rabbit.	1
Possible:	9
Maximum:	6

Teacher Notes

Quotation used by permission.

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 05
UNIT NAME: THEORY OF EVOLUTION

TOPIC: Speciation
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B051KmSA.01
GUIDELINE OBJECTIVE CODE: 51Km
INSTRUMENT TYPE: SA
KLOPFER: A.1, A.2, A.3, A5, A.9
DIFFICULTY LEVEL: H
TIME ALLOCATION:

KEYWORDS: convergent evolution

Guideline Objective

Students will be expected to compare speciation with convergent evolution.

Item Focus

Same as above.

Item

A. Briefly define speciation and convergent evolution.

B. Make a detailed comparison of speciation with convergent evolution. Include what are thought to be the causative forces and give examples of each.

Response/Marking Scheme

A. Speciation: the formation of new species. 1

Convergent evolution: evolution of similar features by unrelated organisms. 1

B.

Speciation	Convergent Evolution
Evolution of different features by organisms which originally shared the same gene pool but no longer do so. 3	Evolution of similar features by genetically incompatible organisms in similar habitats. 3
May be caused by any barrier to genetic change. 1	Since the habitats are similar, organisms are subjected to similar selective pressures 1
Barrier separates two or more groups of an existing species. 1	which will lead to similar adaptations being selected for. 1
Each group will be subjected to different selective pressures from its own particular environment. 1	e.g. the adaptations of thick water retaining stems, with thick cuticles and the reduction of leaf surface area, to reduce water loss by transpiration in cacti, present in all the hot deserts of the world. 3
The groups will simultaneously acquire differences that will eventually reproductively isolate them 1 from each other, should they ever come together again (i.e. they will be different species). 1	or any other appropriate example.
e.g. Darwin's finches, or any other appropriate ex. 2	

Possible: 18

Maximum: 12

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 05
UNIT NAME: THEORY OF EVOLUTION

TOPIC: Adaptation
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B051KnMC.01
GUIDELINE OBJECTIVE CODE: 51Kn
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3, A.5
DIFFICULTY LEVEL: M
TIME ALLOCATION:

KEYWORDS: natural selection resistance to antibiotics

Guideline Objective

Students will be expected to explain the concept of adaptation by describing an example such as the development in bacteria of resistance to antibiotics.

Item Focus

The student should be able to identify an explanation of bacterial resistance to antibiotics in terms of natural selection.

Item

It is known that some antibiotics, such as penicillin, tend to lose their effectiveness in killing certain bacteria if administered too often over a long period of time. Which one of the following is the most likely explanation, based on Darwinian theory?

☐ A. Penicillin is not being made as carefully now as it was when it was first developed.

☐ B. Each bacterium becomes more tolerant to the drug, thereby producing more resistant offspring.

☐ C. Penicillin, improperly administered, assists the bacteria in becoming more resistant.

☐ D. Increased air and water pollution are having an effect on the potency of penicillin.

☐ E. The population has always included a few penicillin-resistant bacteria; these increased to a majority.

Response/Marking Scheme

Correct response: E

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 05
UNIT NAME: THEORY OF EVOLUTION

TOPIC: Adaptation
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B051KnMC.02
GUIDELINE OBJECTIVE CODE: 51Kn
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3, A.5
DIFFICULTY LEVEL: M
TIME ALLOCATION:

KEYWORDS: natural selection resistance to biocides

Guideline Objective

Students will be expected to explain the concept of adaptation by describing an example such as the development in bacteria of resistance to antibiotics.

Item Focus

The student should be able to identify the reason why populations of flies become resistant to a pesticide.

Item

In 1946, a city sprayed DDT on city dumps and other breeding grounds of flies. This was immediately effective in reducing the number of house flies in the whole city area. Although the spraying was repeated in successive years, the number of flies gradually increased, approaching the former (1945) level in 1949. Which one of the following best explains this situation?

☐ A. Each new generation of young flies grew up with DDT as part of the environment and gradually developed immunity.

☐ B. Flies gradually found new breeding places not contaminated by DDT.

☐ C. DDT-resistant flies survived to breed, as did their offspring, until more and more of each year's flies were DDT-resistant.

☐ D. Flies exposed to non-lethal concentrations of DDT quickly learned to avoid food and other matter sprayed with DDT.

☐ E. Flies from nearby, non-sprayed areas soon migrated to the city area.

Response/Marking Scheme

Correct response: C

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B051KnMC.03
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 51Kn
UNIT NUMBER: 05	INSTRUMENT TYPE: MC
UNIT NAME: THEORY OF EVOLUTION	KLOPFER: A.1, A.2, A.3
TOPIC: Adaptation	DIFFICULTY LEVEL: L
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:

KEYWORDS: resistance to antibiotics

Guideline Objective

Students will be expected to explain the concept of adaptation by describing an example such as the development in bacteria of resistance to antibiotics.

Item Focus

The student should be able to identify the mechanism by which resistant bacteria survive when treated with an antibiotic.

Item

When certain bacteria are treated with an antibiotic, resistant strains appear. Which one of the following would best explain this occurrence?

☐ A. The antibiotic causes mutations for resistance to occur.

☐ B. The antibiotic prevents mutations for resistance from appearing.

☐ C. Genes for resistance are already present.

☐ D. The antibiotics reduce the competition from other bacteria, increasing chances for survival.

☐ E. The antibiotics kill all the bacteria normally present, allowing resistant strains to move in.

Response/Marking Scheme

Correct response: C

Teacher Notes

DRAFT

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B051KnER.01
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 51Kn
UNIT NUMBER: 05	INSTRUMENT TYPE: ER
UNIT NAME: THEORY OF EVOLUTION	KLOPFER: A.1, A.3, A.3
	DIFFICULTY LEVEL: M
TOPIC: Adaptation	TIME ALLOCATION:
CURRICULAR EMPHASIS: Solid Foundations	

KEYWORDS: natural selection resistance to antibiotics

Guideline Objective

Students will be expected to explain the concept of adaptation by describing an example such as the development in bacteria of resistance to antibiotics.

Item Focus

The student should be able to use Darwin's theory of natural selection to explain the origin of new strains of bacteria.

Item

Explain the appearance of strains of bacteria resistant to certain antibiotics by natural selection.

Response/Marking Scheme

This can be explained by natural selection, in that with each application of
antibiotic, certain bacteria are capable of surviving. 1
Since the generation time for bacteria is so short, 1
and their reproductive potential is so great, they are 1
experiencing rapid evolution. Through natural selection, those bacteria more
capable of suriviving the antibiotic do so, 1
and pass this information on to the next generation, which 1
undergo the same stresses. Eventually, in what appears to be a short period
of time, but is actually many generations, a new strain appears, resistant to
the 1
antibiotic.

Possible: 6

Maximum: 4

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 05
UNIT NAME: THEORY OF EVOLUTION

TOPIC: Adaptation
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B051KnER.02
GUIDELINE OBJECTIVE CODE: 51Kn
INSTRUMENT TYPE: ER
KLOPFER: A.1, A.2, A.3, A.10. I.5, H.6
DIFFICULTY LEVEL: M
TIME ALLOCATION:

KEYWORDS: natural selection resistance to antibiotics

Guideline Objective

Students will be expected to explain the concept of adaptation by describing an example such as the development in bacteria of resistance to antibiotics.

Item Focus

Same as above.

Item

It has been claimed that infectious diseases contracted in a hospital are more difficult to treat than those contracted elsewhere. Describe two mechanisms by which bacteria can become resistant to antibiotics.

Response/Marking Scheme

Infectious bacteria are as common in a hospital as in any other environment.	1
However, hospital populations are likely to have been exposed to antibiotics.	1
At each exposure, there is a chance that some bacteria will, by chance, bear a mutation that confers	1
resistance to the antibiotic. After numerous exposures	1
and natural selection, an antibiotic resistant strain increases in number. Often, alleles for resistance may	1
be part of a small segment of DNA outside the bacterial	1
chromosome called plasmid DNA. Such plasmids can be transferred from one bacterial species to another.	1
Hence, an infectious agent never exposed to antibiotics can become resistant to it.	1
Possible:	8
Maximum:	6

DRAFT

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B051KnER.03
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 51Kn
UNIT NUMBER: 05	INSTRUMENT TYPE: ER
UNIT NAME: THEORY OF EVOLUTION	KLOPFER: A.1 to 3, A.5, A.8 to 10, D.3, D.6, F.1
TOPIC: Adaptation	DIFFICULTY LEVEL: H
CURRICULAR EMPHASIS: Nature of Science	TIME ALLOCATION:

KEYWORDS: natural selection tolerance graphical analysis

Guideline Objective

Students will be expected to explain the concept of adaptation by describing an example such as the development in bacteria of resistance to antibiotics.

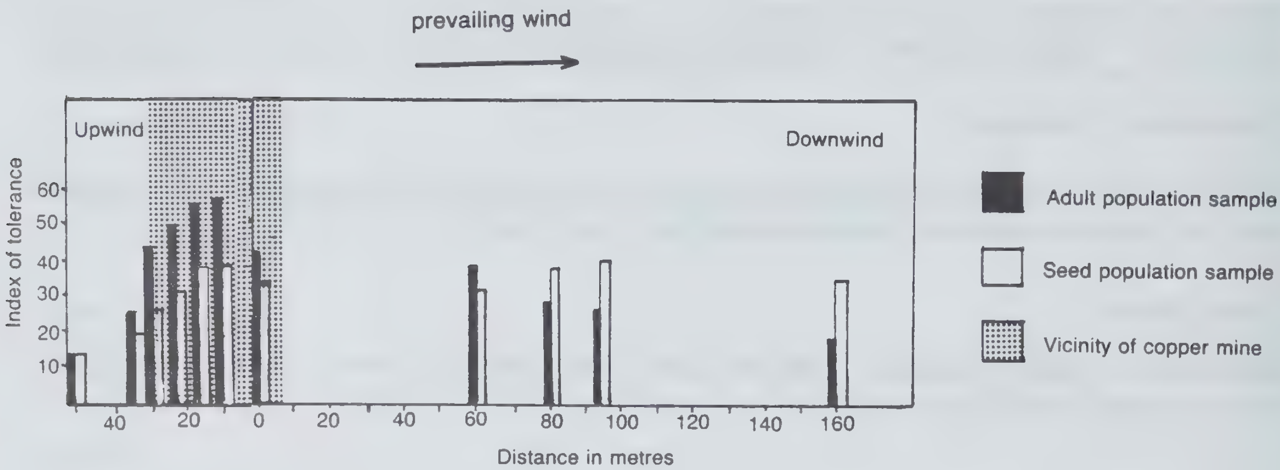
Item Focus

The student should be able to interpret data from a graph in terms of tolerance to an environmental condition, and explain in terms of mutational change.

Item

Refer to Figure 5K.21.

TOLERANCE TO COPPER OF POPULATIONS OF A PLANT NEAR A COPPER MINE



The graph in Figure 5K.21 presents data collected concerning the tolerance of a particular plant, *Agrostis tenuis*to copper in the soil. Copper, while needed in trace quantities, is normally toxic to plants when it occurs in higher concentrations.

Use ecological and/or evolutionary arguments to account for the data about the copper tolerance of plants in the vicinity of a copper mine.

Response/Marking Scheme

Upwind from the mine, there is a genetic equilibrium 1
(Hardy-Weinberg equilibrium), in which adults and seeds have the same inherited tolerance to copper in the soil. 1
Near the mine, and downwind from it, the equilibrium is 1
abolished: there is probably an abnormally high concentration of copper in the soil. 1
Here, individuals having a chance combination of alleles favouring tolerance to copper survive; those without it fail to survive. 1
Hence the surviving adult plants show greater tolerance to copper than those further away. 1
The gene pool, however, is still in a state of disequilibrium, since the seeds show less tolerance than the adults. 1
This is probably due to the fact that, in evolutionary terms, the mine activities have not spread copper-rich residues at the surface for a very long time. 1
Farther downwind from the mine, there is a different type of disequilibrium. 1
Based on observations made on the upwind side, the soil here likely has normal concentrations of copper. 1
However, the alleles for tolerance have entered the gene pool of the downwind populations 1
as shown by the elevated copper tolerance among the seeds. 1
The copper tolerance alleles probably were carried to this area by the wind, either in wind-borne seeds or pollen. 1
The fact that adults in the downwind area show lower tolerance than the seeds generated here 1
suggests that in the absence of elevated copper levels in the soil, non-tolerant individuals have a competitive advantage in the population. 1

Possible: 15

Maximum: 10

Teacher Notes

DRAFT

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B051KnER.04
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 51Kn
UNIT NUMBER: 05	INSTRUMENT TYPE: ER
UNIT NAME: THEORY OF EVOLUTION	KLOPFER: A.1, A.2, A.3, A.9, A.10, B.2, C.1
TOPIC: Adaptation	DIFFICULTY LEVEL: L
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:

KEYWORDS: natural selection resistance to insecticide

Guideline Objective

Students will be expected to explain the concept of adaptation by describing an example such as the development in bacteria of resistance to antibiotics.

Item Focus

The student should be able to explain resistance to pesticides.

Item

When a new insecticide was put to use, many insects showed resistance to it. The inherited resistance resulted in a large population of resistant insects.

Explain why this happened.

Response/Marking Scheme

The resistance was already present in the insect population. Because resistance was inherited, it must have had a genetic basis.	1
The insecticide killed the non-resistant insects, their genes were not passed on in the gene pool.	1
Since only the insects with the alleles for resistance reproduced, these alleles became more frequent in the gene pool.	2
Possible:	4
Maximum:	4

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B051KnLA.01
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 51Kn
UNIT NUMBER: 05	INSTRUMENT TYPE: LA
UNIT NAME: THEORY OF EVOLUTION	KLOPFER: A.1, A.2, A.3, A.4, A.5, A.7, A.9, C.1, C.2, C.3, D.3
TOPIC: Adaptation	DIFFICULTY LEVEL: H
CURRICULAR EMPHASIS: Solid Foundations	TIME ALLOCATION:

KEYWORDS: bacterial resistance natural selection

Guideline Objective

Students will be expected to explain the concept of adaptation by describing an example such as the development in bacteria of resistance to antibiotics.

Item Focus

The student should be able to interpret an experiment designed to illustrate selection as a mechanism of evolution.

Item

A population of bacteria was selected for its resistance to penicillin. Media containing a range of concentrations of penicillin were prepared. The bacteria were transferred to petri dishes containing different concentrations of penicillin in the media.

A. What would you expect to happen to the bacteria?

B. Explain your answer in terms of genetics and natural selection.

Response/Marking Scheme

A. There would be a good growth of bacteria on the media 1

containing the lower concentrations of penicillin, however, as the concentration increased, fewer and fewer colonies would grow. 1

Finally, at very high concentrations, there would be little or no bacterial growth. 1

B. Within populations there is variation and hence heterozygosity as a result of random mutations of the DNA code. 2

These are not always apparent unless the variant is essential for survival. Since bacteria are haploid, phenotypes reflect the genotype (there are no hidden recessives). 1

In this case, the concentration of penicillin is the selective factor. Any bacteria not having a high tolerance to the effects of penicillin will die.
Those that do will survive. 1

Those colonies growing on the highest concentration of penicillin will all contain the alleles for resistance to penicillin. 1

Media with lower concentrations of penicillin could contain some bacteria that managed to survive without the resistant allele. 1

Possible: 9

Maximum: 5

Teacher Notes

DRAFT

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B051KnLA.02
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 51Kn
UNIT NUMBER: 05	INSTRUMENT TYPE: LA
UNIT NAME: THEORY OF EVOLUTION	KLOPFER: A.1, A.2, A.3, A.4, A.5, A.6, D.3, F.1
TOPIC: Adaptation	DIFFICULTY LEVEL: H
CURRICULAR EMPHASIS: Nature of Science	TIME ALLOCATION:

KEYWORDS: natural selection resistance to antibiotics

Guideline Objective

Students will be expected to explain the concept of adaptation by describing an example such as the development in bacteria of resistance to antibiotics.

Item Focus

The student should be able to interpret the results of an experiment illustrating bacterial resistance in terms of natural selection.

Item

In a technique known as replica plating, a sterile velvet cloth was pressed onto a plate containing colonies of one bacterial species. The cloth was then pressed onto 50 sterile agar plates, and 50 sterile agar plates containing a specific antibiotic. After several days, the following observations were made.

Number of Bacterial Colonies

Plates without antibiotic	600
Plates with antibiotic	2

A. What function is served by the plates without antibiotic?

B. What principle is demonstrated by this experiment?

C. Explain the results of the experiment.

D. How might the principle illustrated by this experiment apply to everyday situations?

Response/Marking Scheme

A. The control experiment shows how viable the bacteria are naturally without the effect of the antibiotic. 1

B. Natural selection (OR bacterial resistance to antibiotics). 1

C. Within the original population of bacteria were at least two that differed from the others in their genetics; they carried genes for resistance to the antibiotic. 1

On the normal medium, they were not distinguishable. 1

On the medium containing antibiotic, they were able to survive when bacteria descended from the same ancestor, but lacking resistance were killed. 1

D. Bacteria live in the intestines, and may aid in digestion. When people or domestic animals are treated with antibiotic, the susceptible bacteria will die. 1

Bacteria resistant to the particular antibiotic will be selected to survive. 1

These proliferate to form the entire intestinal flora. 1

If treatment by the same antibiotic is necessary at a later time, these bacteria will not be affected. Animals used for meat, routinely fed antibiotics to suppress disease, become the source of resistant bacteria that can cause serious human infections. 1

The antibiotic residue in the meat also affects sensitive humans. 1

The experiment also demonstrates the danger of selecting resistant populations of bacteria in places where antibiotics are used frequently, such as hospitals. 1

Antibiotics are sometimes used in combination, in an attempt to kill pathogenic bacteria. 1

Possible: 13

Maximum: 8

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B051KnLA.03
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 51Kn
UNIT NUMBER: 05	INSTRUMENT TYPE: LA
UNIT NAME: THEORY OF EVOLUTION	KLOPFER: A.1, A.2, A.3, A.4, A.5, A.7, A.9, C.1, C.2, C.3, D.3
TOPIC: Adaptation	DIFFICULTY LEVEL: M
CURRICULAR EMPHASIS: Nature of Science	TIME ALLOCATION:

KEYWORDS: natural selection resistance to antibiotics graphical analysis

Guideline Objective

Students will be expected to explain the concept of adaptation by describing an example such as the development in bacteria of resistance to antibiotics.

Item Focus

The student should be able to interpret an experiment designed to illustrate selection as a mechanism of evolution.

Item

Refer to Figure 5K.22.

INCREASE IN FREQUENCY OF BACTERIA TOLERANT TO PENICILLIN

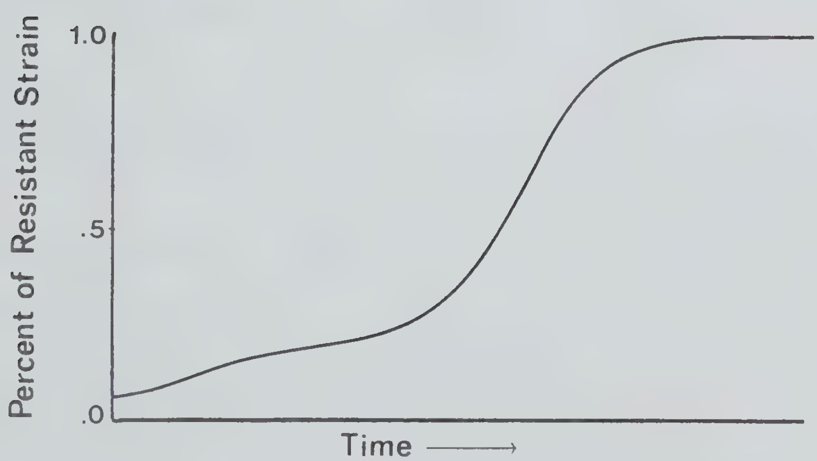


Figure 5K.22 illustrates the frequency of antibiotic-resistant bacteria in a population grown on a medium containing a low concentration of penicillin over several days.

Explain the events illustrated in the graph.

Response/Marking Scheme

Genetic variation exists within the bacterial population. One of these variations is tolerant to penicillin. 1

Initially, before exposure to penicillin, the frequency of the gene for resistance in these bacteria was quite low. 1

Upon exposure to penicillin, some of the non-resitant types died. Most, including the resistant forms, survived, and the frequency of these resistant bacteria increased slightly. 1

As time passed, the resistant forms reproduced vigorously while reproduction among the non-resistant strain slowed down. At this point, the frequency of resistant forms of the bacterium has reached 0.25. 1

Later, the increase in frequency slows until the frequency reaches nearly 1. Very few non-resistant bacteria remain. 1

Theoretically, the frequency will never reach 1. However, in practice, this often does happen, resulting in a population of bacteria that are totally resistant to penicillin. 1

Possible: 6

Maximum: 5

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 05
UNIT NAME: THEORY OF EVOLUTION

TOPIC: Natural Selection
CURRICULAR EMPHASIS: Solid Foundations

INSTRUMENT CODE: B051KnSA.01
GUIDELINE OBJECTIVE CODE: 51Kn
INSTRUMENT TYPE: SA
KLOPFER: A.1, A.2, A.3
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS:

Guideline Objective

Students will be expected to explain the concept of adaptation by describing an example such as the development in bacteria of resistance to antibiotics.

Item Focus

The student should be able to describe factors affecting the study of natural selection.

Item

State three advantages and three disadvantages of microorganisms for studies in natural selection?

Response/Marking Scheme

Advantages: (Accept any three)
-short generation time
-high reproductive potential
-require little space
-large numbers
-easy to induce mutations
-inexpensive

Disadvantages: (Accept any three)
-small and difficult to observe
-few genes to be affected
-generally reproduce asexually, reducing variation
-potentially pathogenic

Maximum: 6

Teacher Notes

DRAFT

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 05
UNIT NAME: THEORY OF EVOLUTION

TOPIC: Punctuated Equilibrium
CURRICULAR EMPHASIS: Nature of Science

INSTRUMENT CODE: B051KoMC.01
GUIDELINE OBJECTIVE CODE: 51Ko
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.2, A.3.
DIFFICULTY LEVEL: L
TIME ALLOCATION:

KEYWORDS: natural selection

Guideline Objective

Students will be expected to compare Darwin's thinking on the progression of the development of species with the hypothesis of "punctuated equilibrium" as proposed by S.J. Gould.

Item Focus

The student should be able to identify the significance of a current controversy among scientists about the interpretation of the fossil record.

Item

One group of scientists maintains that evolution proceeds by many small changes accumulated over very long ages, and sorted by the environment ("Natural Selection"). Another group, re-interpreting the fossil record, maintains that evolution proceeds in spurts — rapid change — followed by long ages of little change ("Punctuated Equilibrium").

What is the best interpretation of this controversy?

☐ A. The theory of evolution should be discarded.

☐ B. Scientists agree that evolution has occurred, but disagree on the mechanisms by which it occurred.

☐ C. Both groups of scientists are wrong.

☐ D. A single contrary fact is enough to disprove a theory.

☐ E. The theory of natural selection has been proved wrong, and should be discarded.

Response/Marking Scheme

Correct response: B

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B051K-MA.01
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 51K-
UNIT NUMBER: 05	INSTRUMENT TYPE: MA
UNIT NAME: THEORY OF EVOLUTION	KLOPFER: A.2, A.3, A.8
	DIFFICULTY LEVEL: L
TOPIC: Review of Concepts	TIME ALLOCATION:
CURRICULAR EMPHASIS: Solid Foundations	

KEYWORDS: adaptation genetic drift Lamarck natural selection species

Guideline Objective

The student will identify terms used in this unit with their definitions.

Item Focus

Same as above.

Item

For each of the terms in the left column, select the number of the most appropriate statement from the right column, and enter it into the blank space.

A. ___	natural selection	1.	random change in gene frequency in a small group.
B. ___	genetic drift	2.	a genetic feature of an organism or any of its parts that results when the environment selects phenotypic variation.
C. ___	Lamarck	3.	inherited trait passed down a family tree for generations.
D. ___	species	4.	a population of similar individuals that interbreeds under natural conditions to produce viable offspring.
E. ___	adaptation	5.	the differential rate of reproduction among variants in a population.
		6.	the record in the rocks containing traces of organisms of long ago.
		7.	the inheritance of traits acquired during an individual's lifetime.

Response/Marking Scheme

Correct responses:

A: 5, B: 1, C: 7, D: 4, E: 2

1 mark each,

Maximum: 5

Teacher Notes

DRAFT

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B051K-MA.02
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 51K-
UNIT NUMBER: 05	INSTRUMENT TYPE: MA
UNIT NAME: THEORY OF EVOLUTION	KLOPFER: A.1, A.2, A.3, A.8
	DIFFICULTY LEVEL: M
TOPIC: Review of Concepts	TIME ALLOCATION:
CURRICULAR EMPHASIS: Solid Foundations	

KEYWORDS:

Guideline Objective

The student should be able to identify concepts taught in the unit on evolution, and state whether the variable is increasing, decreasing or remaining the same.

Item Focus

Same as above.

Item

Answer with the choice of words that best completes the statement. Write the word of your choice in the proper answer space. The choices are:

increase
decrease
remain the same

1. With an increase in the number of offspring produced in a species, the number of variations in the species should____________.
2. The number of mammal species was found to ____________ shortly after the giant dinosaurs became extinct.
3. When a species migrates into a new area, the number of genotypes should____________.
4. If the rate of mutation in a species increases, and other factors remain unchanged, the rate of evolutionary change should____________.
5. As time passes, the rate of radioactive disintegration of uranium will____________.
6. In a stable biological community, the population of a species that produces more surviving offspring than other species should____________.
7. The continued testing of nuclear weapons in the atmosphere is likely to cause the mutation rate in many species to____________.
8. As more tonsilectomies are perfomed in a population, the frequency of tonsils in newborn infants will____________.
9. As an animal species becomes more specialized, its chances of surviving a subsequent environmental change will____________.

Possible: 9

Maximum: 9

Response/Marking Scheme

Correct responses: 1. increase
2. increase
3. increase
4. increase
5. remain the same
6. remain the same
7. increase
8. remain the same
9. decrease

Teacher Notes

DRAFT

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B052b2MC.01
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 52b2
UNIT NUMBER: 05	INSTRUMENT TYPE: MC
UNIT NAME: THEORY OF EVOLUTION	KLOPFER: A.1, A.3, A.11
	DIFFICULTY LEVEL: M
TOPIC: Comparative Anatomy	TIME ALLOCATION:
CURRICULAR EMPHASIS: Solid Foundations	

KEYWORDS: nephron adaptation

Guideline Objective

The student is to gather information on one or more lines of evidence explained by the theory of evolution: comparative anatomy.

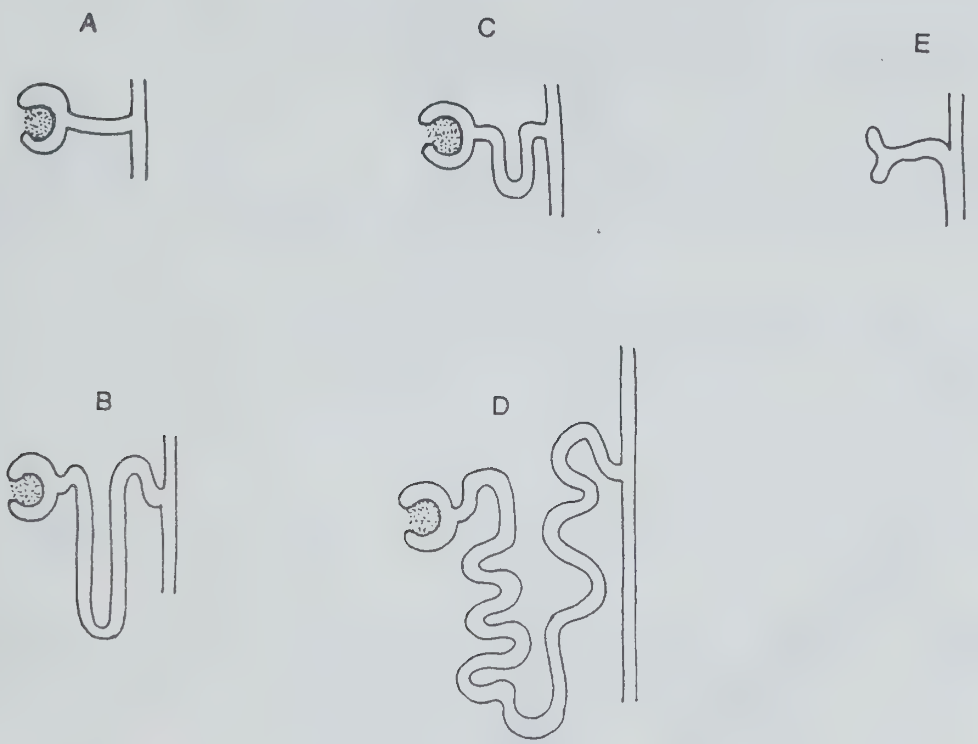
Item Focus

The student should be able to identify adaptations of the nephron for different habitats.

Item

Questions 1 and 2 are based on the following diagrams (Figure 5(2).1) of excretory units (nephrons) in kidneys.

NEPHRONS OF DIFFERENT VERTEBRATE KIDNEYS



Assume that the primary function of the nephron is to reabsorb water.

1. Which nephron is most likely to occur in a freshwater fish?

2. Which nephron is most likely to occur in a desert animal?

Response/Marking Scheme

Correct Response for Question 1: A Correct Response for Question 2: D

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B052b4LA.01
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 52b4
UNIT NUMBER: 05	INSTRUMENT TYPE: LA
UNIT NAME: THEORY OF EVOLUTION	KLOPFER: A1, A2, A3, A7, A8, A9, A10, B1, B3, B5, C2, D3, D5, D6, F1
TOPIC: Biologically Important Molecules	DIFFICULTY LEVEL:
CURRICULAR EMPHASIS: Nature of Science	TIME ALLOCATION:

KEYWORDS: chromatogram comparative biochemistry.

Guideline Objective

Students are to investigate biochemical similarities among living organisms.

Item Focus

The student should be able to apply knowledge of chromatography to problems.

Item

Refer to Figure 5(2).2 to answer this question.

TWO DIMENSIONAL CHROMATOGRAMS

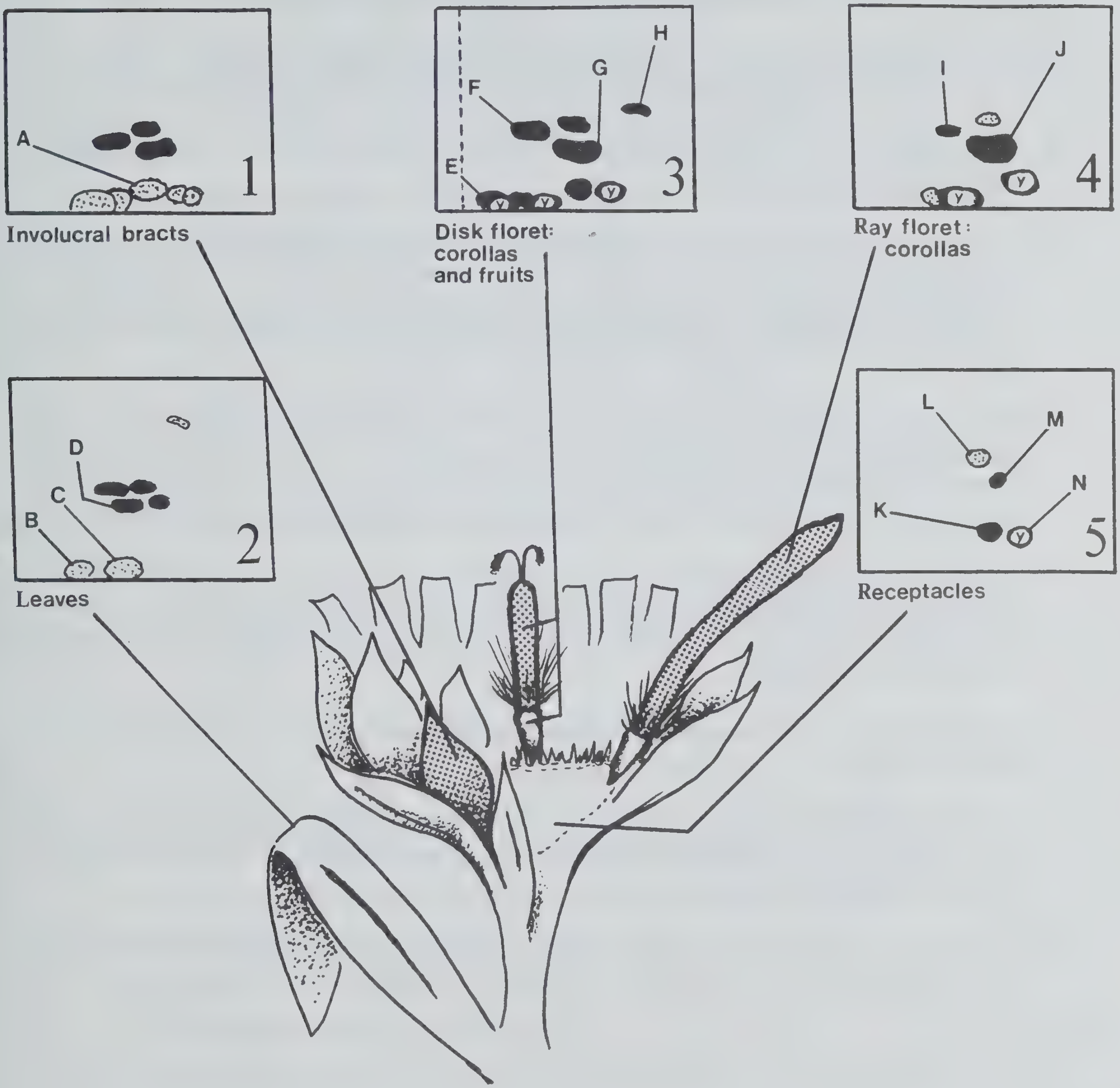


Figure 5(2).2 depicts two-dimensional chromatograms. These were prepared using chemicals extracted by 85% methanol from various parts of a flowering plant related to the sunflower. The extracts were then spotted on the chromatograms, and run with two solvents in two dimensions.

Most of the spots are purple when viewed under ultraviolet light but spots bearing a 'Y' are yellow. The more diffuse the spot in the drawing, the paler the spot.

Note that many spots on the chromatograms bear lettered labels. These will aid you in communicating information efficiently in answering the questions that follows. You need not use all of the letters in your answer, but you can use the same letter twice.

There are also numbers on each chromatogram. These should help you, in your answer, to make rapid references to the different groups of structures in the exercise (Part G).

A. Two labelled spots likely refer to the same chemical. Which two spots are they? Explain how you were able to decide.

B. The technique of two-dimensional chromatography uses two different solvents moving in directions perpendicular to one another (but not simultaneously). This should separate mixtures of chemicals having similar solubilities in one of the solvents. Which spot contains the chemical of greatest solubility difference in the two solvents used? Explain your reasoning.

C. The R_f value might be an indicator of a chemical's solubility in the solvent. Calculate the R_f value for the spot labelled 'G' (Chromatogram #3). Assume that the broken vertical line towards the left of the chromatogram represents the point where the solvent had reached when the chromatogram was stopped. Show all of your calculations.

D. What two chemicals were likely mixed together after chromatography using the first solvent (right to left movement of the solvent) but became separated during the chromatography using the second solvent (bottom to top movement of the solvent)? Explain briefly how you decided.

E. Which single spot contains a chemical having the same R_f in both solvents? Explain how you decided.

F. Of those labelled, which chemical is most widely distributed among the different floral structures studied and which is most restricted in its distribution? Tell where each of the two chemicals are found.

G. Briefly discuss the possible evolution of the various floral structures from one primitive structure. Use evidence from the chromatograms to support your ideas.

Response/Marking Scheme

A. G and J 1

Both have a similar appearance, and, more important, 1

both have reached a similar position on the chromatogram 1

under the influence of two entirely different solvents 1

Give credit for showing knowledge that standard papers and solvent formulations mean that there are standard positions on chromatograms for each chemical 1

Give credit for supporting answer with quantitative data from scales viz 16 units above X-axis and 25 units left of Y-axis. 1

B. E 1

because it has remained at the origin with the vertical solvent and 1

moved furthest away from the origin with the horizontal solvent. 1

Give credit for quantitative support viz 59 units leftward migration 1

C. $R_f = 0.45$ 1

derived by measuring solvent front (55 units) and spot front (25 units) 1

and dividing. (It is a ratio $25/55 = 0.45$) 1

D. D and C 1

Such chemicals would have the same horizontal position but 1

different vertical positions. 1

E. G or J 1

since they move the same distance in each dimension. 1

They must be on a line drawn 45° through the origin. 1

Give credit for pointing out that it must be assumed that the distance travelled by the solvent front was the same in each dimension. 1

F. G or J (M may be acceptable within the accuracy of these drawings.) 1

Found in three groups... #1, #3, and #4 1

and K or L 1

which are found only in the receptacles. 1

G. The intuitive feeling that flower parts are more related to one other than other plant parts 1

is borne out by chemical evidence. There are more 1

chemicals on chromatograms #1, #3, and #4 1

Since chemicals isolated by a single technique (methanol) are likely similar, the number of spots could indicate how similar the parts are chemically and how close in evolutionary history. 1

Actually, five chemicals are shared by #3 and #4 1

and four were shared by these with #1. 1

This suggests that flower "petals" have diverged recently in evolution, and they 1

shared an ancestor with floral bracts before that. 1

Leaves, (#2), share about the same amount with receptacles as with "petals" 1

and receptacles share about as much with "petals" as with leaves. 1

Thus, probably neither leaf nor receptacle is a direct ancestor to the "petals". 1

However, the greater abundance of chemicals in the extracts of leaves than of receptacles 1

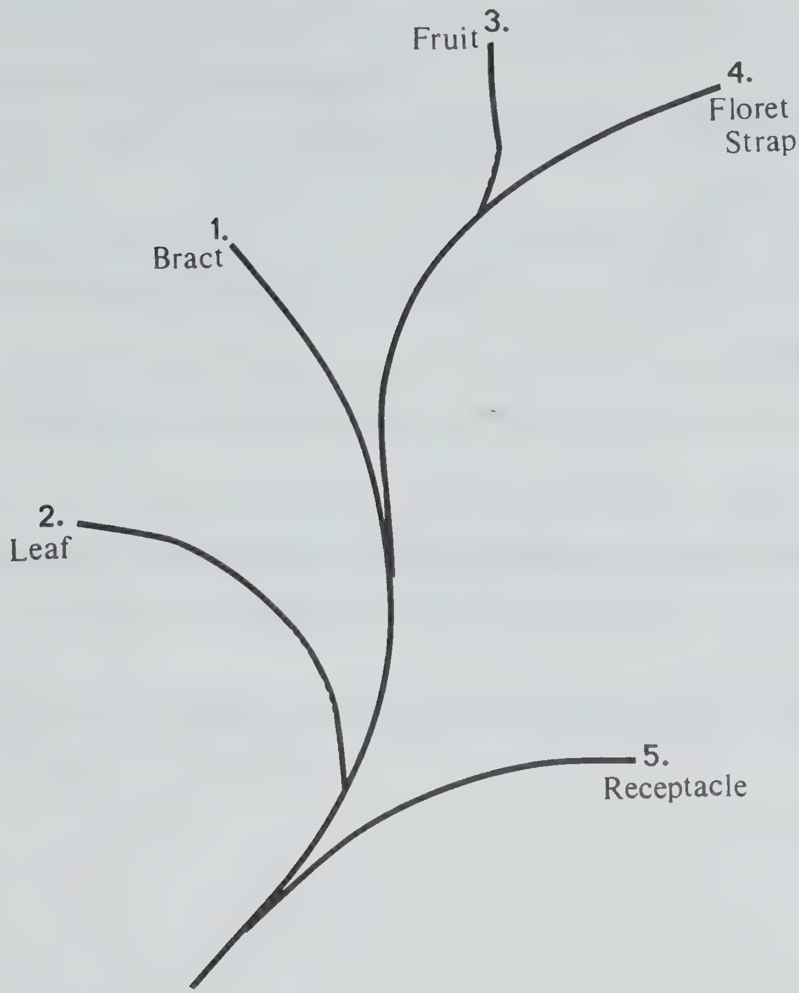
suggests a slightly closer relationship of "petals" to leaves than to receptacles. 1

Give credit for a sketch of an evolutionary tree as indicated on the accompanying diagram, Figure 5(2).3. 1

Possible: 38

Maximum: 25

POSSIBLE EVOLUTION OF PARTS OF A PLANT



Teacher Notes

DRAFT

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B052b7ER.01
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 52b7
UNIT NUMBER: 05	INSTRUMENT TYPE: ER
UNIT NAME: THEORY OF EVOLUTION	KLOPFER: A.1, A.3
	DIFFICULTY LEVEL: M
TOPIC: Selective Breeding	TIME ALLOCATION:
CURRICULAR EMPHASIS: Solid Foundations	

KEYWORDS: artificial selection

Guideline Objective

Students should trace the development of the varieties of domestic animal or plant.

Item Focus

The student should be able to explain how domestication is a form of artificial selection.

Item

Explain how the breeding of dogs or horses illustrates a rapid artificial form of evolution.

Response/Marking Scheme

For centuries, since the dog or horse was first domesticated, breeders have selected phenotypes they judged valuable. 1

These phenotypes may have been particular combinations of alleles, or the result of mutations. 2

Examples of such phenotypes: 2

in horses - greater speed, larger size, stronger

in dogs - running speed, ability to hunt, size, ability to guard or lead, attractive coat.

At every generation, only the most desired animals are allowed to breed. 1

The result has been a gradual shift in the genotypes of particular breeds — the bell curve of phenotypic variability has been moved toward a particular adaptation. 2

This change is a model of natural selection, speeded up because the selection pressures are stronger than in nature. 2

Possible: 10

Maximum: 7

Teacher Notes

DRAFT

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B052c-LE.01
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 52c
UNIT NUMBER: 05	INSTRUMENT TYPE: LE
UNIT NAME: THEORY OF EVOLUTION	KLOPFER: A.1, A.2, A.3, A.5, B.1, B.2, B.3, D.1, D.2, D.3
TOPIC: Variability	DIFFICULTY LEVEL:
CURRICULAR EMPHASIS: Nature of Science	TIME ALLOCATION:

KEYWORDS: continuous variation polymorphic variation.

Guideline Objective

Students are to measure, record and graph continous and noncontinuous (polymorphic) variation in a population. They might examine, for example, variations size, mass, germination rate and coloration in seeds or height, blood type and eye colour in humans.

Item Focus

Same as above.

Item

Introduction:

How do members of a population of a particular species differ from one another? To answer this question, you will be given a "population" of lima bean seeds. Your task is to measure the length of the longest dimension of the seeds, and to sort the seeds into containers by length to establish the variability in this population.

Materials available:

lima bean seeds
ruler
masking tape or labels
5 graduated cylinders or other suitable containers
tray

A. Method

1. Open the package of seeds, and spread the seeds evenly on the tray.

2. Examine the seeds for their variability and select one of the smallest and one of the largest.

3. Measure the maximum length of the two seeds you have selected. Decide on a suitable range of measurements for sorting the seeds by length into the containers, and label each container accordingly. (e.g. Container A: less than 10.0 mm; Container B: 10.1 to 11.0 mm.)

4. Measure the maximum length of each of the seeds in your tray and sort them into the appropriate container.

5. When all of the seeds have been sorted, count and record the numbers in each of the containers. Make a bar graph to represent the variation in this "population" of seeds.

B. Questions

1. What term is used to describe the variation in your sample of seeds?

2. In what way(s) may your sample be representative of the whole population of that variety of plant?

3. In what way(s) may your sample NOT be representative of the whole population?

4. How might this variability have been developed in the population?

Response/Marking Scheme

A. Laboratory technique	2
Selection of a suitable range of measurements	1
Population counts completed and reasonable	1
Bar graph completed	3
Possible:	7
Maximum:	7

B.

1. Type of variation: continuous or non continuous (or other suitable term, such as bimodal, or polymorphic)	1
2. The sample may have been selected randomly	1
and may represent the range of genetic diversity.	1
3. Perhaps the sample is too small,	1
or atypical (not randomly selected)	1
4. Mutation may have arisen by duplication of genes for large size	1
or by errors in copying	1
or by duplication of chromosomes.	1
In spite of selection for larger seeds a random assortment, crossing over, and recombination of several alleles has maintained variability.	2
Possible:	10
Maximum:	7
Total:	17

Teacher Notes

Variation is everywhere! There is no limit to the materials you can make available for your students to measure, record, and graph. Evelyn Morholt, in *A Sourcebook for the Biological Sciences*, 3rd Ed., Harcourt, Brace Jovanovich, Inc., 1986 suggests packages of dried lima bean seeds, mimosa, or locust seeds, sorted by length; striping patterns in sunflower seeds; lengths of maple seeds, evergreen cones, acorns, evergreen needles; widths of leaves of maple, oak, elm; rate of germination of seeds of the same species; widths of mollusc shells; heights and weights of students, sorted by age and sex. Another source had students measure the lengths of the tibia of grasshoppers. Grocery stores have packages of dried seeds: peas, lentils, beans. Try to get about 100 seeds per students. After counting one package, you can use a balance to prepare other packages of about equal mass.

If time for the lab is limited, collect the lab sheets and use the questions that follow the laboratory.

Materials

dried lima bean seeds, several packages (or other available materials)
rulers
masking tape (or labels)
5 containers: graduated cylinders or test tubes and rack
trays

Safety Precautions

none

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B054c-MC.01
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 54c
UNIT NUMBER: 05	INSTRUMENT TYPE: MC
UNIT NAME: THEORY OF EVOLUTION	KLOPFER: A.1, A.2, A.3, I.3
	DIFFICULTY LEVEL: M
TOPIC: Social Consequence of Evolution	TIME ALLOCATION:
CURRICULAR EMPHASIS: Science, Technology and Society	

KEYWORDS: adaptation social consequences

Guideline Objective

The students will point out how scientific theories such as the theory of biological evolution can have a profound effect on the guiding concepts of a society.

Item Focus

Students will recognize examples demonstrating some of the effects of Darwin's theory of biological evolution on society.

Item

Charles Darwin insisted that evolutionary changes led only to increased adaptation (or suitability) of organisms to their external environment, not to inevitable progress towards "higher" forms. Contrary to Darwin's wishes, some people equated evolution with the idea of progress. This false concept has had a number of unfortunate social consequences because:

I it was used to rank human groups and cultures according to their assumed level of evolutionary attainment.

II it was used to justify a social hierarchy during the late nineteenth and twentieth centuries with white Europeans on top and people in conquered colonies on the bottom.

III it could be used to justify the use of less complex primates such as monkeys for harmful physiological experiments.

IV unscrupulous industrialists used the idea to justify their comparative lives of luxury, gained at the expense of underpaid workers.

V many theologians condemned Darwinian evolution as being anti- religious.

Select the most appropriate response from among the following.

☐ A. I only.

☐ B. I, II only.

☐ C. I, II, III only.

☐ D. I, II, III, IV only.

☐ E. I, II, III, IV, V.

Response/Marking Scheme

Correct response: E

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 05
UNIT NAME: THEORY OF EVOLUTION

TOPIC: Scientific Theories
CURRICULAR EMPHASIS: Science, Technology and Society

INSTRUMENT CODE: B054c-ER.01
GUIDELINE OBJECTIVE CODE: 54c
INSTRUMENT TYPE: ER
KLOPFER: A.1, A.3, A.9, A.10, I.5
DIFFICULTY LEVEL: H
TIME ALLOCATION:

KEYWORDS: biological evolution societal concepts eugenics

Guideline Objective

Students will explain how scientific theories such as the theory of biological evolution can have a profound effect on the guiding concepts of a society.

Item Focus

Students will explain aspects the sociological impact of the theory of biological evolution on guiding concepts of society in Europe and North America.

Item

Explain two important ways in which biological evolutionary theory has had a profound effect on guiding concepts of society in Europe and North America.

Response/Marking Scheme

Some segments of society used Darwinian evolutionary theory as a justification of existing hierarchies. 1

For example, some industrialists argued that they were in their positions of power because, through the evolutionary process, they were endowed with greater managerial skills and ability than other people. 1

In the case of aristocracy, those who were born to high positions, claimed that they were naturally endowed with superior intelligence and other social attributes through the evolutionary process. 1

In fact, a number of instances involving supposedly evolutionary traits were used to justify acts of suppression. These examples represented a profound misinterpretation of evolutionary theory. 1

A second major way in which biological evolutionary theory has changed the guiding concepts of society is in the relationship between disciplines such as religion and science. 1

Debates have arisen regarding the "correct" answer as to how the variety of different types of organisms originated. There is a fundamental conflict between those people who believe that there is only one way to interpret natural phenomena. 1

Those who are in bitter conflict wish to forbid the teaching of the other view. 1

However, the debate has initiated a renewed investigation of the nature of a variety of different ways of making sense of our external world. 1

Another possible outcome is in the attempt of humans to direct the course of their own evolution. 1

This in theory could be attempted through the use of genetic knowledge in order to improve the human species through eugenics. This has led to an increase in the number of sperm banks and the frequency of artificial insemination. 1

Possible: 11

Maximum: 8

Quality: 2

Total: 10

Teacher Notes

Curriculum

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B054c-ER.02
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 54c Part 1(3.3m)
UNIT NUMBER: 05	
UNIT NAME: THEORY OF EVOLUTION	INSTRUMENT TYPE: ER
	KLOPFER: A.1, A.3, A.9, H.1, I.1, I.3
TOPIC: Social Impact of Evolution	DIFFICULTY LEVEL:
CURRICULAR EMPHASIS: Science, Technology and Society	TIME ALLOCATION:

KEYWORDS: social consequences of evolution social Darwinism eugenics

Guideline Objective

The student will be expected to develop a rich and exciting view of the universe, the world, and the environment as a result of a knowledge of science, its applications, and its implications.

Item Focus

The student will explain the effect of the theory of biological evolution on science and society.

Item

Since Darwin's theory of biological evolution was published in 1859, this theory has had profound effects on both science and society.

A. List and explain two major effects of the theory of biological evolution on scientific thinking.

B. List and explain two major effects of the theory of biological evolution on society in Europe and North America.

Response/Marking Scheme

A. One important effect has been to further strengthen the concept of the interplay of deduction with induction. 1

The concept of variation and the selection of the best fit between organism and environment has provided a model for the growth of scientific knowledge. 2

The model is that a number of ideas are proposed, and those that best survive attempts to prove them inadequate are tentatively accepted as plausible. 2

Evolutionary concepts have helped to heighten debate between those who believe biological taxonomic systems indicate evolutionary links between organisms, and those who argue that taxonomic systems are classification systems that serve as organizers and mnemonics, but do not enlighten the issue of evolutionary relationships. 2

B. One effect was the appearance of what has been called "social Darwinism". 1

This resulted in a social justification of many of the inhumane and unhealthy conditions that existed in factories while owners and investors lived comparative lives of luxury. 2

Those in positions of authority were thought of as having superior ability through the action of natural selection leading to the "survival of the fittest". 1

Thus, using Darwinian ideas (taken out of context), the uneven distribution of resources was justified. 1

Another effect was the rise of arguments dealing with the topic of eugenics. 1

In this case, eugenicists argued that the reproduction of humans ought to be controlled so that only good variations (genes) would be spread though human populations. 2

This movement took as its inspiration the Darwinian concept of evolution. 1

Possible: 16

Maximum: 12

Quality: 3

Total: 15

Teacher Notes

DRAFT

Curriculum

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 05
UNIT NAME: THEORY OF EVOLUTION

TOPIC: Eugenics
CURRICULAR EMPHASIS: Science, Technology and Society

INSTRUMENT CODE: B054c-ER.03
GUIDELINE OBJECTIVE CODE: 54c
INSTRUMENT TYPE: ER
KLOPFER: 8.1, A.2, A.3, A.10, F.3, I.4, I.5
DIFFICULTY LEVEL:
TIME ALLOCATION:

KEYWORDS: genetics

Guideline Objective

The students will be aware of examples of how scientific theories such as the theory of biological evolution can have a profound effect on the guiding concepts of a society.

Item Focus

The student will articulate both positive and negative aspects of the concept of humans directing their own evolution through the process of eugenics.

Item

It seems possible for humans to direct the course of their own evolution through the application of genetics. The application of genetics knowledge to the improvement of the human species is known as eugenics. The application of eugenics could result in the reduction of certain genetic diseases by preventing people who are carriers of genes that cause genetic diseases from reproducing. On the other hand, people with good genes could be encouraged to reproduce. This could be realized through the use of sperm banks and artificial insemination.

A. State and explain two major arguments in support of humans controlling their evolution through eugenics.

B. State and explain two major arguments against humans controlling their evolution through eugenics.

Response/Marking Scheme

A. One major advantage is that people who have a gene (allele) which is responsible for a genetically inherited disease will not pass the gene (allele) on to future generations, 1

thereby reducing the possibility of the frequency of the gene (allele) increasing within a population. 1

A second advantage of eugenics is the promotion of phenotypes in humans that are considered desirable. 1

For example, through artificial insemination, a woman could be fertilized by a sperm from a father with certain desirable traits. 1

B. The only sure way of ensuring that the people involved will not reproduce is to render the individuals sterile. A major argument against a eugenics programme is the severe loss of personal choice and freedom involved in some state agency telling people that they must not have children. 1

Furthermore, implementation of a non-voluntary sterilization programme significantly restricts individual freedom. 1

Another significant argument against eugenics involves the problem of who decides which traits are desirable and undesirable. 1

Furthermore, the issue of agreement on desirable and undesirable traits would be difficult to deal with because different people might have a variety of viewpoints on the subject. That is, it would be difficult to obtain agreement on the issue. 1

Possible: 8

Maximum: 8

Teacher Notes

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B057c-MC.01
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 57c
UNIT NUMBER: 05	INSTRUMENT TYPE: MC
UNIT NAME: THEORY OF EVOLUTION	KLOPFER: A.1, A.2, A.3, A.5
	DIFFICULTY LEVEL: L
TOPIC: Origin of Life	TIME ALLOCATION:
CURRICULAR EMPHASIS: Nature of Science	

KEYWORDS: Miller

Guideline Objective

Some students might read about and discuss various hypotheses concerning the origin of life, e.g., Oparin's hypothesis, the contributions of Urey and Miller.

Item Focus

The student should be able to identify the conclusions of Stanley Miller about the possible origin of organic materials.

Item

Stanley Miller is credited with demonstrating conclusively that

☐ A. natural selection does occur within populations of domestic animals and plants.

☐ B. reproductive success is the key to an organism's survival.

☐ C. living protoplasm shares many chemical properties with organic solutions.

☐ D. life can be created in a test-tube, given the conditions present on the early Earth.

☐ E. organic compounds can be formed under the conditions believed present on the early Earth.

Response/Marking Scheme

Correct response: E

Teacher Notes

DRAFT

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B057c-ER.01R
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 57c
UNIT NUMBER: 05	INSTRUMENT TYPE: ER
UNIT NAME: THEORY OF EVOLUTION	KLOPFER: A.1, A.2, A.3, A.9, I.1, I.5
	DIFFICULTY LEVEL: M
TOPIC: The Modern Theory	TIME ALLOCATION:
CURRICULAR EMPHASIS: Communication	

KEYWORDS: natural selection

Guideline Objective

Some students might discuss or debate one or more issues related to evolution.

Item Focus

The student should be able to analyze the position of human beings with respect to natural selection.

Item

"Human beings have emancipated themselves from the process of natural selection."

Outline two arguments, one for and the other against the statement above.

Response/Marking Scheme

FOR:

Through modern medicine, humans have induced immunity to many to the natural agents that formerly selected part of the population to survive. 1

People who would not have survived in natural conditions are kept alive with artificial support. 1

Improved nutrition and food aid programs have saved populations that would have succumbed to starvation. 1

In ways such as these, humans have prevented natural selection from removing the less fit from the reproductive gene pool. 2

AGAINST:

Even though humans are keeping the less fit alive, they are still subject to natural selection. 1

Their efforts are selecting a less fit population. 1

By maintaining defective alleles in the gene pool, and 1

increasing their proportion, 1

by keeping alive people with medical condtions (such as hemophilia) that in former ages would have killed them, 1

humans are limiting their flexibility to cope with ecological disasters of the future. 1

Possible: 11

Maximum: 8

Teacher Notes

DRAFT

DISCIPLINE/SUBJECT: Science/Biology	INSTRUMENT CODE: B057c-ER.02R
LEVEL: OAC	GUIDELINE OBJECTIVE CODE: 57c
UNIT NUMBER: 05	INSTRUMENT TYPE: ER
UNIT NAME: THEORY OF EVOLUTION	KLOPFER: A.1, A.2, A.3, A.5, A.10, A.11
	DIFFICULTY LEVEL: M
TOPIC: Future Evolution	TIME ALLOCATION:
CURRICULAR EMPHASIS: Communication	

KEYWORDS: natural selection human influence on evolution

Guideline Objective

The student will be expected to discuss or debate one or more issues related to evolution.

Item Focus

Same as above.

Item

Consider the statement:

"Humans have influenced significantly the direction of evolution for many species."

Indicate <u>three</u> ways in which humans play a role in changing the direction of evolution of other organisms.

Response/Marking Scheme

Any <u>three</u> ways, such as the following, @ 3 marks each:

1. By acting as the selection agent, humans are shaping domestic animals and plants to develop characteristics desirable to us. Genetic engineering will allow us to speed up this process by manipulating desirable genes.

2. By removing the effects of natural selection, humans keep alive animals and plants that would not have been able to survive on their own. This includes veterinary care of domestic animals, and breeding assistance to help endangered wild species to survive.

3. By altering the environment, humans have destroyed many natural habitats, endangering many species, and causing the extinction of others. The over-exploitation of food sources has also destroyed the ecological balance in many ecosystems.

4. Another way of altering the environment is through the production of pollutants. These are inadvertently resulting in extinction and endangered species (e.g., the effect of DDT on egg shells of top predators in food chains). The excess production of carbon dioxide from combustion of fossil fuels has raised the global temperature, and may in time be a selective force.

5. Some human products are mutagens that will increase the number of variant genes in natural populations on which natural selection can act.

6. Introduction of non-native species, such as the starling and the English sparrow into North America, or rabbits to Australia, changes the pressure of competition.

Maximum: $3 \times 3 = 9$

Teacher Notes

DRAFT

DISCIPLINE/SUBJECT: Science/Biology
LEVEL: OAC
UNIT NUMBER: 05
UNIT NAME: THEORY OF EVOLUTION

TOPIC: Immutability of Species
CURRICULAR EMPHASIS: Nature of Science

INSTRUMENT CODE: B057f-MC.01
GUIDELINE OBJECTIVE CODE: 57f
INSTRUMENT TYPE: MC
KLOPFER: A.1, A.3, C.3, D.5
DIFFICULTY LEVEL: M
TIME ALLOCATION:

KEYWORDS: fossil record

Guideline Objective

Students will be expected to compare the origin and central idea of the concept of evolution of species with that of the immutability of species.

Item Focus

The student should be able to identify a test of the hypothesis that species do not change.

Item

If we assume that species do <u>NOT</u> change, we would expect

☐ A. the more complex fossils only in the older rocks.

☐ B. these less complex fossils only in the newer rocks.

☐ C. the same kind of fossils in both old and new rocks.

☐ D. no fossils of any kind in rocks.

☐ E. the less complex fossils only in the older rocks.

Response/Marking Scheme

Correct response: C

Teacher Notes